1.0 Submission of Water Works Plans

Preliminary plans and the engineer's report should be submitted for review prior to the preparation of final plans. All reports, final plans and specifications, along with a letter of transmittal, must be submitted at least 60 days prior to the date on which action by the Department is desired. Permits for construction, waste discharges, stream crossings, etc. may be required from other federal, state, or local agencies. No approval for construction can be issued until final, complete, detailed plans and specifications have been submitted to the Department and found to be satisfactory. Documents submitted for formal approval shall be accompanied by a letter of transmittal and shall include, but not be limited to:

1. Summary of the basis of design
2. Operation requirements, where applicable
3. Detailed plans
4. General layout
5. Specifications
6. Locus map
7. Deed Restriction Affidavit

1.1 Engineer's Report

The engineer's report for water works improvements shall, where pertinent, present the following information:

General Information

1. Description of the existing water works and sewerage facilities
2. Identification of the municipality or area served
3. Name and mailing address of the owner or official custodian
4. Legal authority to undertake the work proposed
5. Discussion of Massachusetts Environmental Policy Act (MEPA) regulations
6. Discussion of Wetlands Protection Act requirements
7. Discussion of water pollution control (waste disposal regulations)

Extent of Water Works System

1. Description of the nature and extent of the area to be served

2. Provisions for extending the water works system to include additional areas

3. Appraisal of the future requirements for service, including existing and potential industrial, commercial, institutional and other water supply needs

Alternate Plans

Where two or more solutions exist for providing public water supply facilities, each of which is feasible and practicable, discuss the alternate plans and give reasons for selecting the one recommended, including technical, financial and managerial considerations and analysis.

Consecutive systems must have a written agreement between the consecutive system and the supplying system. It should address the status and responsibilities of the parties for the ownership, operation and maintenance of the combined system, including but not limited to, drinking water sources, treatment facilities, distribution systems, storage and water quality sampling.

General Conditions

Soil, groundwater conditions, and foundation problems, including a description of:

1. Foundation conditions prevailing at sites of proposed structures

2. Approximate elevation of groundwater in relation to subsurface structures

Water Use Data

1. Description of population trends as indicated by available records and the estimated population that will be served by the proposed water supply system or expanded system

2. Present water consumption and the projected average maximum daily demands used as the basis of design (total and gallons per capita per day (gpcd) for both present and projected using estimated populations)

3. Present and/or estimated yield of the sources of supply

4. Compare gpcd to DEM demand projections

Fire Flow Requirements

1. Requirements of the National Board of Fire Underwriters, or other similar agency on fire flows required or recommended in the service area involved

2. Fire flows that will be made available by the proposed or enlarged system

Sewage System Available

Describe the existing sewerage system and sewage treatment works, with special reference to their relationship to existing or proposed waterworks structures which may affect the operation of the water supply system, or which may affect the quality of the supply.

Source of Water Supply

Describe the proposed source(s) of water supply to be developed, the reasons for selection, and provide information as follows, and discussed in Chapters 3 and 4:

1. Surface Water Sources
    a. Hydrological data, stream flow, and weather records
    b. Safe yield, including all factors that may affect it
    c. Maximum flood flow of record, together with safety features of the spillway and dam
    d. Description of the watershed, noting any existing or potential sources of contamination which may affect water quality
    e. Summarized quality of the raw water with special reference to fluctuations in quality, changing meteorological conditions, etc.

2. Groundwater Sources - All of the following information, with the exception of b and f, should be depicted on U.S. Geological Survey (USGS) topographic maps.
    a. Sites considered
    b. Advantages of the site selected
    c. Elevations with respect to surroundings
    d. Probable character of formations in which the source is to be developed; this should include a delineation of the extent of the aquifer along with a minimum of two geologic cross-sections, one in the direction of groundwater flow and the other perpendicular to groundwater flow
    e. Geologic conditions affecting the site
    f. Summary of source exploration, test well depth, and method of construction placement of liners or screen; test pumping rates and their duration; water levels and specific yield; and water quality
    g. Sources of possible contamination within Zones I, II, III as defined, such as sewers and sewage facilities, landfills, outcropping of consolidated water bearing formations, waste disposal wells.

Proposed Treatment Processes

Adequacy of Proposed Processes - The adequacy of proposed processes and unit parameters for the treatment of the specific water under consideration should be summarized and established. Alternative methods of water treatment and chemical use should be considered as means of reducing waste handling and disposal problems.

1. Pilot Studies - Pilot studies are required to determine the adequacy of the treatment processes to deliver water that meets the standards established by the Department. Pilot studies are also required to determine chemical dosages and other operation related parameters.

2. Normally, the duration of a pilot study covers a 12-month period. However, the Department may require a longer period of study if data obtained in the preceding months is inadequate or unsatisfactory to complete the evaluation process. Similarly, the Department may either waive the requirement of piloting or reduce the duration for a specific site provided that adequate data exists to determine the needed parameters of design and operation.

Waste Disposal

Discuss the various wastes from the water treatment plant, their volume, proposed treatment, points of discharge and/or ultimate disposal location.

Automation

Provide supporting data justifying automatic equipment, including the servicing and operator training to be provided. Manual override must be provided for any automatic controls.

Project Site

1. Discussion of the various sites considered and advantages of the recommended ones.

2. The proximity of residences, industries, and other establishments

3. Discuss potential sources of pollution, within Zones I, II, and III as defined, that may influence the operation of the water works system, such as sewage absorption systems, septic tanks, privies, cesspools, sink holes, sanitary landfill, refuse and garbage dumps.

Financing

1. Estimated cost of integral parts of the system, life expectancy and replacement cost

2. Detailed estimated annual cost of operation, maintenance, and operating personnel
3. Proposed methods to finance both capital charges and operating expenses

Future Extensions

Summarize planning for future needs and services.

1.2 Plans

Plans for water works improvements shall, where pertinent, provide the following:

General Layout

1. Suitable title
2. Name of municipality, or other entity or person responsible for the water supply
3. Area or institution to be served and locus
4. Graphic scale, in feet
5. North arrow
6. Datum used and local bench mark
7. Date plans were prepared, including all revision dates
8. Imprint of professional engineer's seal and signature of engineer showing registration in Massachusetts.
9. Legible print suitable for filing
10. Location and size of existing water mains
11. Location and nature of existing water works structures and appurtenances affecting the proposed improvements, noted on one sheet

Detailed Plans

1. Stream crossings, providing profiles with elevations of the stream bed and the normal and extreme high and low water levels

2. Profiles having a horizontal scale of not more than 100 feet to the inch and a vertical scale of not more than 10 feet to the inch, with both scales clearly indicated

3. Location and area of the property to be used for the groundwater development with respect to known references such as street intersections

4. Topography and location(s) of present or planned wells or structures with contour intervals not greater than 2 feet, plus a minimum of two geologic cross-sections, one in the direction of groundwater flow, and the other perpendicular to it.

5. Elevations of the highest known flood level, floor of the structure, upper terminal of protective casing and outside surrounding grade, using United States Coast and Geodetic Survey, United States Geological Survey or equivalent elevations, where applicable, as reference

6. Drawings of well construction, showing diameter and depth of drill holes, casing and liner diameters and depths, grouting depths, elevations and designation of geological formations, water levels and other details to describe the proposed well completely

7. Location of all existing and potential sources of pollution within 400 feet and major sources of pollution within 1/2 mile of the source and within 100 feet of underground treated water storage facilities

8. Size, length, and identity of sewers, drains, and water mains, and their locations relative to plant structures

9. Schematic flow diagrams and hydraulic profiles showing the flow through various plant units

10. Piping in sufficient detail to show flow through the plant, including waste lines

11. Locations of all chemical feeding equipment and points of chemical application (see Section 6.0, *Chemical Application*)

12. All appurtenances, specific structures, equipment, water treatment plant waste disposal units, and points of discharge having any relationship to the plans for water mains and/or water works structures

13. Locations of sanitary or other facilities, such as lavatories, showers, and toilets, where applicable or required

14. Locations, dimensions, and elevations of all proposed plant facilities

15. Locations of all sampling taps

16. Adequate description of any features not otherwise covered by the specification

17. New facilities should address all actual and potential cross-connections. (see Section 9.9)

18. Existing facilities should conduct a cross-connection survey and take appropriate corrective action where necessary. (see Section 9.9)

1.3 Specifications

Where pertinent, complete, detailed technical specifications shall be supplied for the proposed project, including:

1. A program for keeping existing water works facilities in operation during construction of additional facilities so as to minimize interruption of service

2. Laboratory facilities and equipment

3. The number of chemical feeders (see Section 6.1)

4. Materials or proprietary equipment for sanitary or other facilities including any necessary backflow or back-siphonage protection

5. A table of contents or index for easy reference

1.4 Design Criteria

A summary of complete design criteria shall be submitted for the proposed project, containing, but not limited to, the following:

1. Long-term dependable yield of the source of supply

2. Reservoir surface area, volume, and a volume-versus-depth curve, if applicable

3. Area of watershed

4. Estimated average and maximum daily water demands for the design period

5. Number of proposed services

6. Fire fighting requirements

7. Flash mix, flocculation, and settling basin capacities

8. Retention or detention

9. Unit loadings

10. Filter area and the proposed filtration rate

11. Backwash rate

12. Feeder capacities and ranges

13. Finished water storage capacity, if applicable

1.5 Revisions to Approved Plans

Any deviations from approved plans or specifications affecting the capacity, hydraulic conditions, operating units, functioning of water treatment processes, or quality of water to be delivered must be approved by the Department before initiating. Revised plans or specifications must be submitted in time to permit the review and approval of such plans or specifications before beginning any construction work that will be affected by such changes.

1.6 Deed Restriction

The owner of a transient non-community public water system or any other public water system, if deemed necessary by the Department, shall complete an affidavit containing the same information as that found in Appendix B. The person shall record a notarized copy of the same in the appropriate Registry of Deeds. Said recorded Affidavit shall be referenced in the margin of the Deed holder's deed referencing the Book and Page number of the recorded Affidavit. The public water system must provide the Department with a copy of the completed notarized and recorded deed.

2.0 General Design Considerations

The design of a water supply system or treatment process encompasses a broad area. Application of this part is dependent upon the type of system or process involved. See other relative sections in this document for specific requirements.

Facility Layout

The design shall, at a minimum, consider the following:

1. Functional aspects of the plant layout

2. Provisions for future plant expansion

3. Provisions for expansion of the plant waste treatment and disposal facilities

4. Access roads

6. Site grading

7. Site drainage

8. Driveways

9. Chemical delivery

10. Layout of sanitary waste lines to prevent contamination of water

11. For groundwater sources treating for secondary standards, bypass of the treatment units are permitted, provided that adequate safeguards are taken with regard to cross connection control between treated and untreated water. Under no circumstances shall bypasses be opened, unless the appropriate Regional Office is contacted and grants verbal approval. Disinfection of the unused section of piping between the bypass and the treated water piping may be required, along with flushing through external hydrants prior to opening.

12. For surface water and groundwater sources treating for primary standards, bypasses of the facility are prohibited. The Department will allow the installation of a bypass arrangement, provided that a physical separation is accomplished. Bypasses may be constructed to allow insertion of a spool piece during an emergency, but only after receiving verbal approval from the Department. The water supplier must follow up with written notification to the Department. Bypass arrangements shall contain appropriate valving, metering, and disinfection capabilities, with safeguards taken to prevent entry by unauthorized personnel.

Building Layout

The design shall provide:

1. Adequate ventilation
2. Adequate lighting
3. Adequate heating
4. Adequate drainage
5. Dehumidification equipment, if necessary
6. Accessibility of equipment for operation, servicing, and removal
7. Flexibility of operation
8. Operator safety
9. Convenience of operation
10. Chemical storage and feed equipment in a separate room to reduce hazards and dust problems
11. Employee facilities

Location of Structures

No structures shall be located that will impede normal or flood stream flow without specific written approval of the Department. All siting shall be done in accordance with 310 CMR 22.04 (Massachusetts Drinking Water Regulations).

Electrical Controls

Main switch gear electrical controls shall be located above grade.

Standby Power

Standby power is required at all water treatment facilities unless it can be demonstrated that the community has the ability to provide the maximum daily demand for up to 24 hours by other means. This may include the combined ability of other sources to provide the maximum daily demand through existing or new emergency power generation at those sources, from storage tanks, or through a viable interconnection with another public water supplier that is part of an emergency plan approved by the Department.

Shop Space and Storage

Adequate facilities should be included for shop space and storage consistent with the designed facilities.

Laboratory Equipment

Laboratory equipment and facilities shall be compatible with the raw water source, intended use of the treatment plant and the complexity of the treatment process involved.

1. Testing equipment provided shall be adequate for the purpose intended and recognized procedures must be used.

2. Sufficient bench space, ventilation, lighting, storage room, laboratory sink, and auxiliary facilities shall be provided. Air conditioning may be necessary.

Monitoring Equipment

1. Facilities treating surface water should have the capability to monitor and record turbidity, the disinfectant residual, and pH continuously. For systems using slow sand filtration, the Department may reduce the sampling frequency to no less than once per day if it determines that less frequent monitoring is sufficient to indicate effective filtration performance.

2. For surface water treatment facilities serving more than 3,300 people, the disinfectant residual must be monitored continuously. Facilities serving 3,300 people or less, may substitute grab samples for disinfectant residual.

3. Groundwater treatment facilities that remove iron and/or manganese and serve more than 3,300 people shall have the capability to monitor and record free chlorine residual, if required, pH, and pressure. For facilities serving 3,300 people or less, grab samples may be substituted.

4. Facilities adjusting the pH of the water by chemical addition shall have the capability to monitor and record pH continuously if they serve more than 3,300 people. For facilities serving 3,300 people or less, grab samples may be substituted if approved by the Department.

5. Facilities with continuous monitoring equipment should have alarm capabilities to notify operator or appropriate staff in the event of a treatment malfunction.

Sample Taps

Sample taps shall be provided so that water samples can be obtained from each water source and from appropriate locations in each unit operation of treatment. Sample taps must be labeled. Taps shall be consistent with sampling needs and shall not be of the petcock type. Taps used for obtaining samples for bacteriological analysis shall be of the smooth-nosed type without interior or exterior threads, shall not be of the mixing type, and shall not have a screen, aerator, or other such appurtenance.

Facility Water Supply

The facility water supply service line and the plant finished water sample tap shall be supplied from a source of finished water at a point where all chemicals have been thoroughly mixed. Generally, the facility can meet this requirement if the source of finished water is located at least 100 feet downstream from the last point of chemical injection; however, in choosing this location, consideration must be given to the flow rate and the pacing equipment used for chemical injection.

Wall Castings

Consideration shall be given to providing extra wall castings built into the structure to facilitate future uses whenever pipes pass through walls of concrete structures.

Meters

All systems shall have an acceptable means of metering and totaling the finished water and calibrating meters.

Piping Color Code

To facilitate identification of piping in plants and pumping stations, it is recommended that the following color scheme be used:

Water Lines		
	Raw	Olive green
	Settled or Clarified	Aqua
	Finished or Potable	Dark blue
Chemical Lines		
	Alum	Orange
	Ammonia	White
	Carbon Slurry	Black
	Chlorine (Gas and Solution)	Yellow
	Fluoride	Light blue with red band
	Lime Slurry	Light green
	Potassium Permanganate	Violet
	Sulfur Dioxide	Light green with yellow band
Waste Lines		
	Backwash Waste	Light brown
	Sludge	Dark brown
	Sewer (sanitary or other)	Dark grey
Other		
	Compressed Air	Dark green
	Gas	Red
	Other Lines	Light grey

In situations where two colors do not have sufficient contrast to easily differentiate between them, a 6-inch band of contrasting color should be painted on one of the pipes at approximately 30-inch intervals. The name of the liquid or gas should be painted on the pipes. In some cases it may be advantageous to paint arrows indicating the direction of flow.

Disinfection

All wells, pipes, tanks, and equipment, which can convey or store potable water shall be disinfected in accordance with AWWA procedures or other procedures approved by the Department. Plans and specifications shall outline the procedure and include the disinfectant dosage, contact time, and method of testing the results of the procedure. After disinfection, one or more water samples shall be submitted to a Massachusetts or EPA certified laboratory for bacteriological analyses. Satisfactory results shall be reported to the Department prior to placing the well, pipe, tank, and/or other facility in service.

Manual and Parts List

An operation and maintenance manual, including a parts list and parts order form, shall be supplied to the water works as part of any propriety unit installed in the facility. The operation and maintenance manual shall be submitted to the Department for approval before a water treatment facility goes on-line and should conform to *Policy 93-02, Operation and Maintenance Manuals*.

Operator Certification and Instruction

1. Provision shall be made to ensure:
    a. that the facility or PWS is under the direct supervision of an operator who holds a valid certification equal to or greater than the classification of the treatment facility and/or the distribution system;
    b. that the operator(s) in responsible charge must hold a valid certification equal to or greater than the classification of the PWS;
    c. that all operating personnel making process control/system integrity decisions about water quality or quantity that affect public health be certified; and
    d. that a designated certified operator be available for each operating shift as prescribed by 310 CMR 22.11B.

2. Provision shall be made for operator training at the start-up of a plant or pump station.

Other Considerations

Consideration must be given to the design requirements of other federal, state, and local regulatory agencies for items such as safety requirements, special designs for the handicapped, plumbing, and electrical codes.

3.0 Surface Water Supply Development

A surface water supply includes all tributary streams and drainage basins, natural lakes, and artificial reservoirs or impoundments used as sources of water by a public water system. In selecting the source to be developed, the design engineer must prove to the Department's satisfaction that an adequate quantity of water will be available and that the water delivered to consumers will meet all state drinking water standards with respect to microbiological, physical, chemical, and radiological qualities. Each water system should draw its raw water from the best available source that is economically reasonable and technically possible.

3.1 Approval of a New Surface Water Source in an Existing Water Body

Step 1: Submit Preliminary Report

The public water supplier must submit a report to the Department that includes the following:

1. Topographic map showing the exact locations of the proposed source and the proposed intake

2. Map of appropriate scale delineating the tributaries and Zones A, B, and C as described in the *Definitions* section

3. Identification of land uses in the watershed and identification of the land owned or controlled by the public water supplier

4. Estimated average daily demand and peak daily demand

5. Schedule for development of the source

6. Detailed estimated cost of operation, maintenance, and operating expenses

7. Proposed methods to finance both capital charges and operating expenses

Step 2: Conduct Site Visit

The Department will conduct a site visit after the water supplier has gathered the proper information from the property owners and obtained any necessary approvals for visiting the site. At the site exam, the Department will evaluate the proposed sampling locations and schedule to be used during the development of the source.

Step 3: Attend Coordination Meeting

The Department will arrange a coordination meeting with the programs whose approval may be needed. Meeting participants will include, but not be limited to:

- The Department Wetlands Program (including dredging program)
- The Department Water Management Act Program
- MEPA Office
- DEM (concerning the safety of existing dams or surface impoundments)
- DFWELE Natural Heritage Program
- Army Corps of Engineers

The main goal of this meeting is to establish a schedule for getting the necessary approvals from all programs involved.

Step 4: Submit Formal Documentation

The following information must be submitted to the Department before a new surface water source can be approved:

1. Safe Yield Analysis - For stream dominated sand and gravel reservoirs, the safe yield will be estimated by using the safe yield model as described in the Water Management Program document *Estimating the Firm Yield of a Surface Water Reservoir Supply System in Massachusetts, A Guidance Document*, Version 1.0, January 1996. For non-stream dominated reservoirs, a pumping test will be conducted to determine the safe yield and will comply with the following criteria:

    a. The pumping test shall be conducted for a minimum of 30 days.

    b. The pumping test shall be conducted at 133% of the rate at which approval is sought.

    c. The approved pumping rate will be based on the rate at which stabilization occurs.

    d. Reservoir water level measurements will be taken twice daily (frequency of measurements will be at least 8 hours apart).

    e. Stabilization will have been achieved when either:

        (1) drawdown readings do not fluctuate more than 0.5 inch in the last 24 hours of the test; or
        (2) when using a semi-log plot extrapolation of the time-drawdown curve derived from the pumping test and projected over a 180-day period, and 10% of the water height between the top of the intake and the static water level remains above the intake.

f. As constant a pumping rate as possible shall be maintained for the duration of the pumping test. The pumping rate shall not fluctuate more than 10% during the final 10 days of the pumping test, excluding shutdowns.

g. One pump shutdown per day not to exceed 1 hour shall be allowed during the 30-day test period. If the shutdown criteria are exceeded, the Department will require the pumping test to be rerun; therefore, backup pumping equipment is recommended.

h. A flow-measuring device capable of providing instantaneous flow measurements accurate to within ±3% of the pumping rate shall be used.

i. The discharge from the pumping test shall be located to minimize the recirculation of water. Any groundwater discharge permits should be obtained prior to commencement of the pumping test.

j. Static water level measurements will commence 7 days prior to pumping test startup.

k. The pumping test should be conducted during low water level conditions.

l. Precipitation during the pumping test should be measured on site to the nearest one-hundredth (0.01) of an inch. Precipitation measurements should commence 7 days prior to pumping test startup.

m. Recovery reading shall be taken twice daily (frequency of measurements at least 8 hours apart) for a period of no less than 10 days following pumping test shutdown.

2. Hydrogeologic Report - Discuss the hydrogeologic system providing recharge to the reservoir and include a delineation of the drainage basin. If applicable, a fracture trace analysis of the reservoir area should be provided.

3. Identification of Dredging Impacts

4. Water Quality Monitoring Report - The water supplier must submit a report describing the required monitoring at this time, the water supplier may also elect to perform any additional monitoring required by *Policy 90-04, Pilot Study Requirements for Proposed Treatment*.

   The water supplier must conduct the following monitoring at a location as close as possible to the proposed intake:

   a. Fecal and Total Coliform - Weekly for 1 year (If interested in filtration waiver, frequency of sampling is population dependent (3 - 5 times/week)
   b. Turbidity, Color, Odor, Temperature, Suspended and Total Dissolved Solids - Weekly (If interested in a filtration waiver, turbidity must be done

Daily for one year)
c. Secondary Contaminants (as listed in Appendix A) - Addressing reservoir turnover, typically spring and fall
d. All SDWA Contaminants - Taken during spring turnover
e. Total Organic Carbon - Seasonally
f. *Giardia* and *Cryptosporidium* - Every other month
g. Nitrogen Series (nitrate, nitrite, ammonia) - Monthly
h. THM Formation Potential - Monthly in July, August, and September
i. Algae - Monthly throughout the year at intake, major tributaries and at one or more locations in the reservoir.

5. Watershed Resource Protection Plan - Guidance can be found in the document *Developing a Local Surface Water Supply Protection Plan, DEP,2000.*

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6. Proposed Treatment Plan - Every surface water supply is subject to the federal Surface Water Treatment Rule (SWTR), as written in 310 CMR 22.20A of the Massachusetts Drinking Water Regulations. The water supplier must submit a report discussing how it plans to meet the requirements of the SWTR. If planning to filter, treatment of the source must be determined through piloting according to *Policy 90-04, Pilot Study Requirements for Proposed Treatment*.

   If a public water supplier is interested in a filtration waiver as specified in 310 CMR 22.20A, the water supplier must pursue development of a watershed resource protection plan. The plan must meet the criteria defined in *Policy 89-09, Preparation of a Watershed Resource Protection Plan,* and must be developed on a dual track with the treatment plant design. The water supplier must meet all criteria to avoid filtration. In addition, the water supplier must discuss how the system will provide disinfection in the interim if a waiver from filtration is pursued.

7. Operation and Maintenance Manual-for management of the source

3.2 Development of New Reservoirs

Construction and Maintenance

1. Reservoirs must be constructed to ensure that:
   a. Water quality is protected by controlling runoff into the reservoir
   b. Dikes are structurally sound, free of significant vegetation, and protected against wind action and erosion
   c. The point of influent flow is separated from the point of withdrawal
   d. Separate pipes are provided for influent to and effluent from the reservoir
   e. The volume of water in storage can be determined at all times

2. Dams must receive appropriate safety approval from DEM.

3. Construction may require:

    a. Approval from the Department and DEM, as necessary, of the safety features for stability and spillway design
    b. A permit from the Department and other regulatory agencies for controlling streamflow or installing a structure on the bed of a stream or interstate waterway

Site Preparation

Site preparation for the reservoir shall include, where applicable:

1. Removal of brush and trees up to high water elevation

2. Protection from floods during construction

3. Proper abandonment and decommissioning (Section 4.14) of all wells and other structures or other facilities that will be inundated

4. Erosion minimization during development of the source

Intake Structures and Design

Intake structures and design shall include:

1. Intake screens

2. Withdrawal of water from more than one level if quality varies with depth

3. Separate facilities for release of less desirable water held in storage

4. Where ice may be a problem, holding the velocity of flow into the intake structure to a minimum, generally not to exceed 0.5 feet per second

5. Manholes every 1000 feet for pipe sizes large enough to permit visual inspection

6. Cleaning of the intake pipe and screen, as needed

7. Adequate protection against rupture by ice and other potential hazards

8. Location of the intake above the bottom of the stream, lake, or impoundment, but at sufficient depth to be kept submerged at low water level

3.3 New Feeder Reservoirs

1. The water supplier must meet all applicable requirements in Section 3.0.

2. Proposals for new feeder reservoirs must address physical and chemical changes to the terminal reservoir and any effects on existing treatment.

3. Both the terminal reservoir and the feeder reservoir must be monitored during the approval process.

4.0 Groundwater Supply Development and the Source Approval Process

Editor's note: This chapter, pp. 20-113, is being revised and will be available in the annual update of the Guidelines in 2002. Refer to the *Guidelines and Policies, 1996*, for specific text. You may also visit the DEP Web site: www.state.ma.us/dep.

5.0 Treatment

Engineering Report

An initial engineering study documented in an engineer's report shall be submitted in conformance with Section 1.1, *Engineer's Report*, prior to submittal of piloting and design documents.

Pilot Facility Studies

After approval of the engineer's report, a pilot study or in-plant demonstration study shall be conducted. The study must be conducted in accordance with Policy 90-04. Before preparing design plans and specifications, a final report including the engineer's design recommendations, shall be submitted to the Department for review and written approval.

Final Requirements for the Treatment Facility

A. Before the treatment facility goes on-line, the following items must be completed:

1. *Water Quality Tests* - In addition to the required monitoring to evaluate the efficacy of treatment, sampling must be conducted for volatile organic chemicals, inorganics (including lead and copper), and bacteria.

2. *Initial Inspection* - Conducted by the Department's Regional Office.

3. *Operation and Maintenance Manual* – Submitted in compliance with Policy 93-02, and must include an emergency response plan.

4. *Operator Staffing Plan* – Plan addresses compliance with 310 CMR 22.11B.

5. *Determination of Compliance* - that addresses compliance with the requirements in the Approval letter from the Department's Regional Office; A punchlist of items to be completed by the water supplier may be prepared before final approval.

B. Before approval of the treatment facility, the following items must be completed :

1. *Final Inspection* - Conducted by the Department's Regional Office.

2. *Contact Time (CT) Tracer Study*; within 60 to 90 Days, Efficiency values for CT calculation are needed.

3. *As-Built Plans* – These plans should be available on site once the facility is completed.

Optimization of Water Treatment Facility Performance

The water treatment facility performance must be optimized continuously for water to be free of pathogenic organisms such as *Giardia* and viruses.

The following should be incorporated into optimization evaluations of water treatment facilities:

1. Turbidity Performance Goal – This goal is for purposes of evaluation by the operator's staff only. A turbidity performance goal of 0.1 NTU level in effluent waters should be used during design flows for extended periods of time.

2. Settled Water Turbidities of less than 2.0 NTU to assure meeting maximum loading rates on filters.

3. Filtered Water Turbidities after backwash of less than 0.3 NTU for less than 20 minutes.

4. Required Contact Time in accordance with EPA's *Surface Water Treatment Rule Guidance Manual.*

5. Operational Flexibility to handle a variety of water quality situations.

6. Management Techniques to obtain accepted operation and maintenance standards for the treatment facility.

5.1 Facility Design

General Information

If failure of the treatment facility would result in an inability to meet the maximum daily demand, plants designed for processing surface water shall:

1. Provide minimum of two units each for rapid mix, flocculation and sedimentation.

2. Consider a design that would permit operation of the rapid mix and flocculation tanks in either series or parallel.

3. Be constructed to permit units to be taken out of service without disrupting operation, and with drains or pumps sized to allow dewatering in a reasonable period of time.

4. Provide multiple-stage treatment facilities when required by the Department.

5. Minimize hydraulic head losses between units to allow future changes in processes without the need for repumping.

6. Maintain the application of a coagulant to effectively coagulate and flocculate the water at all times when a treatment plant is in operation. Proper process and operational procedures should be used at the plant to assure that chemical feeds are adjusted and maintained in response to raw water temperature, turbidity, and other variations in water quality.

7. Disinfect all water treatment facilities that are taken out of service for inspection, repairing, painting, cleaning, or other activity that might lead to contamination of water, before they are returned to service. Disinfection must be conducted in accordance with AWWA standard C-653.

Presedimentation

Waters containing high turbidity may require presedimentation either with or without the addition of coagulation chemicals. The feasibility and effectiveness of presedimentation should be specifically addressed in the engineer's report for review by the Department.

1. Basin Design - Presedimentation basins should have hopper bottoms or be equipped with continuous mechanical sludge removal apparatus, and provide arrangements for dewatering.

2. Inlet - Inlets shall be designed to distribute the water evenly and at uniform velocities; short circuiting must be prevented.

3. Bypass - Provisions for bypassing presedimentation basins shall be included.

4. Detention Time - Two to four hours detention is the recommended time, greater or lesser detention may be required, based on piloting or bench scale evaluations.

Rapid Mix

Rapid mix shall mean the rapid and even dispersion of chemicals throughout the water to be treated, usually by violent agitation. The engineer shall submit the design basis for the velocity gradient (G Value) selected, considering the chemicals to be added, water temperature, color and other related water quality parameters.

1. Equipment - Static or mechanical mixing devices may be approved along with any other method proven by piloting evaluations. Variable speed mechanical mixing devices should be considered.

2. Mixing - The detention period should be such as to yield a velocity gradient of 600 to 1000 fps/ft for mechanical mixing.

3. Location - The rapid mix and flocculation basins shall be as close together as possible.

4. Accessibility - Each rapid mix basin or device shall be constructed for easy observation and access.

5. Chemical Feed - Chemicals shall be applied at such points and by such means as to insure satisfactory mixing of the chemicals with the water. Preliminary design documents, submitted with the piloting report, should contain diagrams of proposed application points of all chemicals.

Flocculation

Flocculation shall mean the agitation of chemically treated water at low velocities for periods of time to encourage formation of floc particles.

1. Basin Design - Inlet and outlet design shall minimize short-circuiting between flocculation and sedimentation basins and also prevent the destruction of floc. Basins shall be designed for sludge removal by dewatering, pumping, gravity drainage or other methods.

2. Detention - Detention time for floc formation should be 20 to 30 minutes. Greater or less detention time may be allowed, based on piloting.

3. Equipment - Agitators shall be driven by variable speed drives with the peripheral speed of paddles or walking beam flocculator ranging from 0.5 to 3.0 ft/sec.

4. Piping - Flocculation and sedimentation basins shall be as close together as possible. The velocity of flocculated water through pipes or conduits entering settling basins shall not be greater than 1.5 feet per second. Allowances must be made to minimize turbulence at bends and changes in direction to maintain floc.

5. Cleaning - A water supply of sufficient quantity shall be available in reasonable proximity to the flocculation and sedimentation basins.

6. Superstructure - A cover or enclosure over the flocculation basins may be required to protect against weather and contamination. A watertight access hatch should be installed to allow access and observation. Hatches should be sized to allow installation and removal of basin equipment components.

7. Accessibility - Each flocculation basin shall permit observation and easy access.

8. Safety - Permanent ladders or handholds should be provided on the inside walls of basins and shall comply with latest OSHA regulations. Guard rails should be provided for any floors or walkways adjacent to open basins.

9. Chemical Feed - Installation of chlorine feed points in flocculation basins is recommended to allow for shock dosing for maintenance purposes.

10. Underwater Light - To assist in determining flocculant presence, effective size, and density, an underwater light should be installed in flocculation chambers approximately 12 inches below the normal water level of the basin.

Sedimentation

Sedimentation may follow flocculation. The detention time for effective clarification depends upon a number of factors related to basin design, hydraulic flows and the nature of the raw water. The following criteria apply to conventional sedimentation units:

1. Detention Time - Should provide between 2 to 4 hours of settling time at maximum flow rate, depending on raw water quality and pre-treatment chemistry to be used. Reduced detention time may be approved if equivalent effective settling is demonstrated, during piloting or bench evaluations.

2. Inlet Devices - Inlets to sedimentation basins shall be designed to distribute the water equally and at uniform velocities. Open ports, submerged ports, and similar entrance arrangements are required. Baffles should be constructed across the basin close to the inlet end and should project several feet below the water surface to dissipate inlet velocities and provide uniform flows through the basin.

3. Outlet Devices - Outlet devices shall be designed to maintain velocities suitable for settling in the basin and to minimize short-circuiting.

4. Weir Overflow Rate - Recommended weir rates not to exceed 20,000 gallons per day per foot of weir length. A higher number will be considered where justified. Where submerged orifices are used as an alternate for overflow weirs, they should not be lower than 3 feet below the flow line with flow rates equivalent to weir loadings.

5. Surface Overflow Rate - The overflow rate shall not exceed 800 gal/day/ft^2. Higher rates may be allowed based on evaluation of water quality settling characteristics and filter loading rates.

6. Velocity - The velocity through sedimentation basins should be between 0.5 and 3.0 ft/min. The basins must be designed to minimize short-circuiting. Baffles may be provided as necessary, to control velocities and short-circuiting.

7. Overflow - An overflow weir (or pipe) shall be installed at an elevation above the maximum desired sedimentation basin height. Gravity discharge of overflow waters will be discharged or directed to reservoirs, lagoons or Department approved locations.

8. Superstructure - A cover or enclosure over the sedimentation basins may be required to protect against weather and contamination. A watertight access hatch should be installed to allow access and observation. Hatches should be sized to allow installation and removal of basin equipment components.

9. Residuals Collection - Mechanical residuals collection equipment is recommended to prevent reintrainment of residuals. The residuals collection equipment should not disturb the settled solids. Acceptable means include traveling screens, sludge scrapers or vacuum systems.

10. Residuals Removal - Residuals removal design shall provide that:

    a. Sedimentation basin floors should be sloped to a central collection point or trough to facilitate drainage and residuals removal.
    b. Residuals removal should comply with general requirements *Residuals Removal* in this chapter.

11. Flushing Lines - Flushing lines or hydrants shall be provided and must be equipped with backflow prevention devices acceptable to the Department.

12. Safety - Permanent ladders or handholds should be provided on the inside walls of basins and shall comply with latest OSHA regulations. Guard rails should be provided for any floors or walkways adjacent to open basins.

13. Residuals Disposal - Methods of residuals disposal should be identified. Residuals disposal shall be done in accordance with local, state, and federal requirements.

14. Chemical Feed - The installation of chlorine feed points in sedimentation basins is recommended to allow shock dosing for maintenance purposes.

Tube Settlers

Tube settler units, consisting of variously shaped tubes or plates that are installed in multiple layers and at an angle to the flow, may be used for sedimentation, following flocculation. Effectiveness of the settling unit should be demonstrated by piloting. General criteria are:

1. Inlet and Outlet Considerations - Design to maintain velocities suitable for settling in the basin and to minimize short-circuiting.

2. Drainage - Drain piping from the settler units must be sized to facilitate a quick flush of the settler units and to prevent flooding other portions of the plant.

3. Protection from Freezing - A cover or enclosure should be provided to protect against weather and contamination.

4. Application Rate - The recommended rate should be 1 to 3 gal/min/ft2 of cross-sectional area (based on 24-inch-long 600 tubes or 39.5-inch-long 7-1/20 tubes), unless higher rates are successfully demonstrated through pilot plant or in-plant demonstration studies.

5. Flushing Lines - Water and/or air flushing lines shall be provided to facilitate routine flushing of floc buildup in and/or above the tubes. Water lines in the basins must be properly protected against backflow or back siphonage.

6. Residuals Removal - Mechanical residuals removal should be provided.

Solids Contact Unit

Units are generally acceptable for clarification where water characteristics, especially temperature, do not fluctuate rapidly, flow rates are uniform, and operation is continuous. Before such units are considered as clarifiers, approval of the Department shall be obtained. Clarifiers should be designed for the maximum uniform rate and should be adjustable for changes in flow that are less than the design rate and for changes in water characteristics. A minimum of two units are required for surface water treatment.

1. Chemical Feed - Chemicals shall be applied at such points and by such means as to insure satisfactory mixing of the chemicals with the water. Preliminary design documents, submitted with the piloting report, should contain diagrams of proposed application points of all chemicals.

2. Mixing - A rapid mix device or chamber upstream of solids contact units may be required by the Department to assure proper mixing of the chemicals applied. Mixing devices shall:

    a. Provide good mixing of the raw water with previously formed residuals particles,
    b. Prevent deposition of solids in the mixing zone.

3. Flocculation - Flocculation equipment:

    a. Shall be adjustable (speed and/or pitch).
    b. Must provide for coagulation in a separate chamber or baffled zone within the unit.
    c. Should provide the flocculation and mixing period of no less than 20 minutes

4. Residuals Concentrators

    a. The equipment should provide either internal or external concentrators in order to obtain a concentrated residual with a minimum of wastewater.
    b. Large basins should have at least two sumps for collecting residuals with one sump located in the central flocculation zone, provided as a means for draining.

5. Detention Period - The detention time shall be established on the basis of the raw water characteristics and other local conditions that effect the operation of the unit. Based on design flow rates, the detention time within the mixing zone and settling zone should be between 2 and 4 hours. The Department may allow alternative detention time requirements on the basis of successful pilot study results.

6. Suspended Slurry Concentrate - Softening units should be designed so that continuous slurry concentrates of 1% or more by weight can be satisfactorily maintained.

7. Water Losses - Units shall be provided with suitable controls for residuals withdrawal.

8. Weirs or Orifices - The units should be equipped with either overflow weirs or orifices constructed so that water at the surface of the unit does not travel over 10 feet horizontally to the collection trough.

    a. Weirs shall be adjustable and at least equivalent in length to the perimeter of the tank.
    b. Weir loading shall not exceed 10 gal/min/ft of weir length for units used for clarifiers.
    c. Where orifices are used the loading per foot of launder rates should be equivalent to weir loadings. Either shall produce uniform rising rates over the entire area of the tank.

9. Upflow Rates - The upflow rates should be 1.0 gal/min/ft^2 of area at the sludge separation line for units used for clarifiers. The Department may allow higher upflow rates on the basis of successful pilot study results.

10. Pulsating or Upflow Rates - Pulsating or upflow types of settling units may be used for clarifyng sedimentation of flocculated waters. The piloting study shall identify and justify this type of construction. These types of units shall contain all provisions outlined under the general requirements of solid contact units.

Dissolved Air Flotation

Dissolved air flotation (DAF) is a clarification process that is based on the transfer of particles to the surface of a liquid through attachment of bubbles to the particle surface. The particles are removed as floating solids by mechanical skimming. The piloting evaluation shall identify and justify this type of solids removal.

1. DAF may be recommended when waters contain high levels of low-density particles such as algae.

2. The typical DAF process train consists of chemical and air injection, flocculation, flotation, and skimming.

3. A portion of the flotation tank effluent is recycled, pressurized, and saturated with air.

4. Surface loading rates ranging from 3 to 5 gpm/ft^2 are recommended. Higher loading rates must be demonstrated through piloting.

5. Baffling is required at the tank influent to direct the incoming flow toward the tank surface while reducing its velocity to minimize disturbance of the floating residual layer.

Contact Adsorption Clarifier

Contact adsorption clarifier combines coagulation, flocculation, and clarification processes into a single upflow adsorption clarifier. The clarifier uses contact flocculation/adsorption to remove turbidity.

1. A media loading rate should be determined based on piloting data.

2. Effective media size is typically 4 to 6 mm, and media depth is generally 4 feet. Use piloting results to determine media size and bed depth.

Residuals Removal - General

Residuals removal design shall provide that:

1. Residuals withdrawal lines should be adequately sized for proper use. It is recommended they be at least 4 inches in diameter and arranged to facilitate cleaning.

2. Entrance to residuals withdrawal piping shall minimize clogging.

3. Valves shall be located outside the tank for accessibility.

4. The operator may observe and sample residuals being withdrawn from the unit.

Treated Water Storage or Clearwell

The water supply works (includes all treatment facilities and sources of supply) should be capable of delivering, in connection with the storage on the distribution system, the maximum daily consumption plus the required fire flow. Accordingly, required clearwell storage should be sized, taking into account the present storage needs to meet the aforementioned requirement, as recommended by AWWA and the Insurance Services Organization (ISO).

The following should apply for sizing and operation:

1. The operator should be able to safely shut down the treatment train and/or facility during periods of mechanical failure and/or during periods of allowed unoperated supervision.

2. The clearwell should allow the system to have continuity of flow through the filters for each treatment train at uniform rates during all conditions of system demand at or below the approved filtration rate.

3. The clearwell should be able to guarantee continuity of service during adverse raw water conditions without bypassing the system.

4. Baffling is recommended to increase plug flow zone in the basin and minimize short-circuiting to meet CT requirements of the Surface Water Treatment Rule.

5. Overflows may be discharged directly back to surface waters and should be equipped with the appropriate level of instrumentation. Overflow elevations should be designed to prevent flooding of the water treatment facility.

5.2 Filtration

Acceptable Filters

Acceptable filters shall include the following:

1. Dual and mixed media
2. Granular activated carbon
3. Deep bed anthracite or coarse sand
4. Diatomaceous earth

Filtration Processes

Many filtration processes should be considered and may include the following:

1. Rapid rate gravity filters
2. Direct filtration
3. Diatomaceous earth filtration
4. Slow sand filtration
5. Pressure filters

The application of any one type must be supported by water quality data representing a reasonable period of time to characterize variations in water quality. Pilot studies may be required to demonstrate the applicability of the method of filtration proposed.

General Design and Operation

To ensure compliance with the Surface Water Treatment Rule:

1. Filtration facilities shall provide a continuous turbidimeter with recorder to monitor the effluent turbidity from each individual filter and in the composite filter effluent line. Access should be made for taking regular grab samples. If continuous monitoring is impractical, routine monitoring of individual filters is recommended as a minimum.

2. New treatment facilities shall have the capability of filter-to-waste whenever a filter is put on-line, initially and following backwash.

3. Filters removed from service for extended periods of time should be backwashed upon start-up and, where possible, provided with an increased dosage of disinfectant to the effluent.

4. Additional credit for log removal inactivation up to 0.5 log removal may be considered for filtration facilities other than conventional facilities. Credit will be given for the completion and maintenance of an approved watershed control program that reduces the potential for source water contamination.

Rapid Rate Gravity Filters

1. Number of Filters - If the water system is dependent upon the proposed facility to meet the average daily demand, at least two separate filtering units with bypasses to one another shall be provided. Where only two units are provided, each shall be capable of meeting the plant design capacity (normally the projected maximum daily demand) at the approved filtration rate. Where more than two filter units are provided, the filters shall be capable of meeting the plant design capacity at the approved filtration rate with one filter removed from service.

2. Rate of Filtration - Average filtration rates should not exceed 3 gal/min/ft^2 except that higher rates may be allowed through consideration of such factors as raw water quality control, monitoring for turbidity and other parameters, staffing, and other factors as required by the Department. In any case, the filter rate must be proposed and justified by the designing engineer to the satisfaction of the Department prior to the preparation of final plans and specifications.

3. Structural Details and Hydraulics - The filter structure shall be so designed as to provide for:

   a. Vertical walls within the filter
   b. No protrusion of the filter walls into the filter media
   c. Cover by superstructure

d. Trapped effluent to prevent backflow of air to the bottom of the filter
e. Prevention of floor drainage to filter with a minimum 4-inch curb around the filters
f. Prevention of flooding by providing overflow
g. Washwater drain capacity to carry maximum flow
h. Walkways around filters, cannot be less than 24 inches wide
i. Safety handrails or walls around filter areas adjacent to normal walkways
j. Construction to prevent cross connections and permeable common walls between potable and non-potable water
k. Accessibility by the operator to obtain samples from the effluent channels or sampling pumps

4. Washwater Troughs - Washwater troughs shall be so designed as to provide

   a. The elevation of the bottom of the troughs shall be determined based upon the type of backwashing process i.e., air and water or water alone. In no instance shall the bottom of the trough interfere with the expansion of the media
   b. A level top edge
   c. Spacing so that each trough serves the same number of square feet of filter area
   d. Maximum horizontal travel of suspended particles to reach the trough not to exceed 4 feet

5. Filter Bottoms and Strainer Systems - The design of manifold-type collection systems shall:

   a. Minimize loss of head in the manifold and laterals
   b. Assure even distribution of washwater and even rate of filtrate collection over the entire area of the filter
   c. Provide the ratio of the area of the final openings of the strainer systems to the area of the filter at about 0.003
   d. Provide the total cross-sectional area of the laterals at about twice the total area of the final openings
   e. Provide the cross-sectional area of the manifold at 1-1/2 to 2 times the total area of the laterals

   Note: Departures from these standards may be acceptable for high rate filters and for proprietary bottoms.

6. Surface Wash Facilities - Surface wash facilities are recommended and may be accomplished by a system of fixed nozzles or a revolving type apparatus. All devices shall be designed with:

   a. Provisions for operating water pressures of at least 45 psi for pressure filters and 20 psi for gravity filters
   b. A properly installed approved device to prevent back siphonage, if connected to the treated water system

c. Rate of flow between 2.0 to 4.0 gallons per minute per square foot of filter area with fixed nozzle or 0.5 to 1.0 gal/min/ft² with revolving arms

7. Air Scouring - Air scouring can be considered in place of surface wash providing it meets the following conditions:

   a. Air flow for air scouring the filter must be 2 to 5 standard cubic feet per minute per square foot.
   b. Concurrent washwater rates must not exceed 8 gal/min/ft² unless a method of retaining the filter media is provided. The maximum rate should be determined based on the type of media used and the amount of time that is desirable for cleaning the media when using air and water in combination.
   c. If dual media is used, air scouring must be followed by a fluidization wash sufficient to restratify the media.
   d. Air must be protected against contamination, from compressor or exhausts or other potential contaminants.
   e. No air wash piping shall be placed in the filter media, unless approval of piping and backsiphonage valving is obtained from the Department.
   f. Underdrain and air manifold shall be designated to accommodate air and water backwash.
   g. Provisions of Section 5.2, *Rapid Rate Gravity Filters*, *Backwash* shall be followed.

8. *Appurtenances*- Every filter shall have:

   a. Provisions for sampling and observation of influent and effluent waters, where applicable.
   b. An indicating loss of head gauge.
   c. An indicating rate of flow meter for raw water. A modified rate controller that limits the rate of filtration to a maximum rate may be used. However, equipment that simply maintains a constant water level on the filters is not acceptable, unless the rate of flow into the filter is properly controlled. A pump or a flow meter in each filter effluent line may be used as the limiting device for the rate of filtration only after consultation with the Department.
   d. A continuous turbidity monitoring recording device for surface water treatment plants.
   e. A 1 to 1-1/2 inch pressure hose and storage rack within the filter room for washing filter walls with hot water, if available.
   f. Wall sleeves providing access to the filter interior at several locations for sampling or pressure sensing.
   g. Provisions for draining the filter to waste when gravity drains are not installed. Appropriate measures for backflow prevention such as an air gap should be used.

   Note: Subsections b and c may not apply to automatic continuous backwash filters and shall be determined by the Department.

9. Backwash - Provisions shall be made for backwashing filters as follows:

a. A recommended rate of 10 to 20 gal/min/ft², dependent upon type of media and consistent with water temperature and specific gravity of the filter media. A rate of flow to provide for a 50% expansion of a granular activated carbon filter bed and up to 30% expansion for other medias is recommended.
b. Filtered water shall be provided at the required rate by washwater tanks, a washwater pump, clearwell, or a combination of these. Use of a high service main may be allowed but only with a pressure regulating valve to prevent high pressure damage to the underdrain system and disruption of the media.
c. Washwater pumps in duplicate unless an alternate means of obtaining washwater is available.
d. Sufficient storage of filtered water to backwash one filter at the maximum rate.
e. A rate of flow controller or valving, with totalizing capability, as a minimum shall be provided on the main washwater line to obtain the desired rate of filter wash.
f. Rate of flow controls shall be designed to prevent rapid changes in backwash water flow.

Note: Subsections a, c, d, and e do not apply to automatic, continuous backwash filters.

10. Miscellaneous

a. Roof drains shall not discharge into the filters, basins, or conduits within the water treatment facility
b. It is recommended that granular activated carbon filters should have water jet carbon education hardware, including hoses for removal and replacement of media although manual replacement by the manufacturer will be accepted.

11. Filter Media - Filter media shall be clean silica sand or other natural or synthetic media approved by the Department. Other media and media depths will be considered based on pilot test data and specifications and operating data. Types of filter media include:

a. Anthracite - Clean crushed anthracite or a combination of anthracite and other media may be considered on the basis of pilot test data specific to the project, and shall have:
   (1) Effective size of 0.6-1.6 mm depending on the intended use
   (2) Uniformity coefficient of not greater than 1.5
b. Sand - Sand shall have:
   (1) Effective size of 0.35 mm to 0.55 mm
   (2) Uniformity coefficient not greater than 1.65
c. Granular Activated Carbon - Use of granular activated carbon as a filter media, must be justified by the following criteria:
   (1) During piloting or design, various types of granular activated carbon shall be tested for optimum effectiveness, on the water(s) being treated for absorption capabilities.

(2) Contract specifications should provide for AWWA standards recommendations for iodine testing to determine activated levels of granular activated carbon, prior to installation.

(3) Based on testing results, each bed of granular activated carbon should be tested annually, at a minimum, to determine adsorption capacity and filtering effectiveness.

(4) Particle size, specific gravity and adsorptive capacities of granular activated carbon shall be based on site specific needs. Piloting and design evaluation should take into account the nature of the water to be treated, particular treatment process used and pre-filtering treatment processes.

(5) Effective size of granular activated carbon shall be from 0.35 mm to 1.30 mm.

(6) Surface loading rates and bed depth should be based on piloting results.

(7) Uniformity coefficient should not exceed 2.1, after filter backwash.

d. Gravel - Gravel when used as the supporting media, shall consist of hard, rounded particles and shall not include flat or elongated particles. The coarsest gravel shall be 2-1/2 inches in size when the gravel rests directly on the strainer system, and must extend above the top of the perforated laterals. Not less than four layers of gravel shall be provided in accordance with the following size and depth distribution when used with perforated laterals:

Size	Depth
2-1/2 to 1-1/2 inches	5-8 inches
1-1/2 to 3/4 inches	3-5 inches
3/4 to 1/2 inches	3-5 inches
1/2 to 3/16 inches	2-3 inches
3/16 to 3/32 inches	2-3 inches

Reduction of gravel depths may be considered upon justification to the Department when proprietary filter bottoms are specified.

e. Multi and Mixed Media - Filtration by other media, using types as multi media and mixed media as an innovative technology, will be considered based on pilot plant study data and operational experience in New England.

Pressure Filters

The use of these filters is not recommended for surface supplies and is generally not approved since their effectiveness is easily reduced and their operation difficult to monitor. However, they may be approved on a case by case basis as conditions warrant.

1. General

    a. Minimum criteria relative to number, rate of filtration, structural details and hydraulics, filter media, etc., provided for rapid rate gravity filters also apply to pressure filters where appropriate

    b. The specific media shall be approved by the Department

2. Rate of Filtration - The rate should not exceed piloting recommended rates. In any case the filter rate must be proposed and justified by the designing engineer to the satisfaction of the Department prior to the preparation of final plans and specifications.

3. Details of Design - The pressure filters shall be designed to provide for:

    a. Pressure gauges on the inlet and outlet pipes of each filter.

    b. A direct read flow indicator meter on each filtering unit and intake piping.

    c. Piping and valving design shall be arranged to allow for filtration, back-washing, air scouring and drain down of the filter.

    d. A minimum side wall shell height of 5 feet. A corresponding reduction in side wall height is acceptable where proprietary bottoms permit reduction of the gravel depth, and chemical contact times are acceptable.

    e. The top of the washwater collectors to be at least 18 inches above the surface of the media, to minimize media discharge.

    f. The underdrain system to efficiently collect the filtered water and to uniformly distribute the backwash water at a rate recommended for that approved media and filter.

    g. Readable backwash flow indicators and solenoid valve and operating controls.

    h. An air release valve on the highest point of each filter.
    i. Two accessible manholes of sufficient size to allow human access to facilitate inspections and repairs.

    j. Provisions should be made to observe and sample the wastewater during backwash.

    k. Construction shall prevent cross-connection.

l. A pressure relief valve shall be installed for each filter and on the main effluent discharge line from the facility.

Diatomaceous Earth Filtration

The use of these filters may be considered on the basis of successful pilot test results.

1. Types of Filters - Pressure or vacuum diatomaceous earth filtration units will be considered for approval. However, the vacuum type is preferred for its ability to accommodate a design which permits observation of the filter surfaces to determine proper cleaning, damage to a filter element, and adequate coating over the entire filter area.

2. Number of Filters - If the water system is dependent on the proposed facility to meet the average daily demand, at least two units shall be provided. Where only two units are provided, each shall be capable of meeting the plant design capacity (normally the projected maximum daily demand) at the approved filtration rate. Where more than two filter units are provided, the filters shall be capable of meeting the plant design capacity at the approved filtration rate with one filter removed from service.

3. Precoat

   a. Application - a uniform precoat shall be applied hydraulically to each septum by introducing a slurry to the tank influent line and by employing a filter-to-waste or recirculation system.

   b. The recommended quantity of precoat is 1 kg/m² (0.2 pound per square foot) of filter area, and the minimum thickness of the precoat filter cake is 3 mm to 5 mm (1/8 to 1/5 inch).

4. Body Feed - A body feed system by use of a slurry tank, demixer and hopper shall be provided to apply additional amounts of diatomaceous earth slurry during the filter run to avoid short filter runs or excessive head losses.

   a. Quantity - Rate of body feed is dependent upon raw quality and characteristics and must be determined in the pilot plant study.
   b. Operation and maintenance can be simplified by providing accessibility to the feed system and slurry lines with provisions for flushing.
   c. Continuous mixing of the body feed slurry is required.

   d. Coagulant to coat body feed to improve removal rates for viruses, bacteria and turbidity.

5. Filtration

   a. Rate of Filtration - The recommended nominal filtration rate is

1.0 gal/min/ft² of filter area with a recommended maximum of 1.5 gal/ min/ft². Alternative rates may be accepted based on results from the pilot plant study.

b. Head Loss - The head loss shall not exceed 30 psi for pressure diatomaceous earth filters, or a vacuum of 15 inches of mercury for a vacuum system.

c. Recirculation - A recirculation or holding pump shall be used to maintain differential pressure across the filter when the unit is not in operation in order to prevent the filter cake from dropping off the filter elements. A minimum recirculation rate of 0.1 gal/min/ft² of filter area shall be provided.

d. Septum or Filter Element - The filter elements shall be structurally capable of withstanding maximum pressure and velocity variations during filtration and backwash cycles, and shall be spaced such that not less than one inch is provided between elements or between any element and a wall.

e. Inlet Design - The filter influent shall be designed to prevent scouring of diatomaceous earth from the filter element.

6. Backwash - Two air compressors, one as backup, shall be provided to thoroughly remove and dispose of spent filter cake during periods of backwash.

7. Appurtenances - The following shall be provided for every filter:

   a. Sampling taps for raw and filtered water
   b. Loss of head or differential pressure oil filled gauges
   c. Rate-of-flow indicator, preferably with totalizer
   d. A manual and automatic controlled throttling valve to control flows
   e. Body feed, recirculation, and any other pumps required to insure the operation of the treatment system

Slow Sand Filtration

The use of this filtration technology shall require a piloting study to demonstrate the adequacy and suitability of this method of filtration for the raw water supply to be treated, unless waived by the Department.

1. Number of Filters - At least two units shall be provided. Where only two units are provided, each shall be capable of meeting the plant design capacity (normally the projected maximum daily demand) at the approved filtration rate. Where more than two filter units are provided, the filters shall be capable of meeting the plant design capacity at the approved filtration rate with one filter removed from service.

2. Structural Details and Hydraulics - Slow rate gravity filters shall have:

   a. A cover

b. Headroom to permit normal movement by operating personnel for scraping and sand removal operations
c. Adequate manholes, ladders and access ports for handling of sand
d. Valving and piping to allow for filtration to waste
e. An overflow to an approved location at the maximum filter water level elevation

3. Rates of Filtration - The permissible rates of filtration shall be determined by the quality of the raw water and shall be on the basis of pilot plant study data derived from the water to be treated. The nominal rate may be 45 to 150 gallons per day per square foot of sand area, with somewhat higher rates accepted based on piloting results.

4. Underdrains - Each filter unit shall be equipped with a main drain and an adequate number of lateral underdrains to collect the filtered water. The underdrains shall be spaced so that the maximum velocity of the water in the lateral underdrain will not exceed 0.75 ft/sec. The maximum spacing of the laterals shall not exceed 12 feet.

5. Filtering Material

   a. Filter sand shall be placed on graded gravel layers for a minimum depth of 30 inches.
   b. The effective size shall be between 0.15 mm and 0.35 mm.
   c. The uniformity coefficient shall not exceed 2.5.
   d. The sand shall be clean and free from foreign matter.

6. Filter Gravel - The supporting gravel shall conform to the size and depth distribution provided for rapid rate gravity filters (refer to Section 5.2. *Rapid Rate Gravity Filters, Filter Media*).

7. Depth of Water on Filter Beds - Design shall provide a depth of at least 3 feet of water over the sand. Influent water shall be distributed by use of weirs or inlets designed to prevent scouring of the sand surface during filling.

8. Operating Requirements - Maintenance of a slow sand filter involves two periodic tasks:

   a. Removal of the top 2 to 3 cm (0.8 to 1.2 inches) of the surface of the sand bed when the headloss exceeds 1 to 1.5 m.
   b. Replacement of the sand when repeated scrapings have reduced the depth of the sand to approximately one-half of its design depth.

Direct Filtration

Direct filtration refers to the filtration of a surface water without prior settling. The nature of the treatment process will depend upon the raw water quality. A full scale direct filtration plant shall not be constructed without prior pilot studies that are acceptable to the Department. In-plant demonstration studies may be appropriate where conventional treatment plants are converted to direct filtration. Where direct filtration is proposed, an engineering report shall be submitted prior to conducting pilot plant or in-plant demonstration studies.

Prior to the initiation of design plans and specifications, a final report including the engineer's design recommendations shall be submitted to the Department.

1. Pretreatment: Rapid Mix and Flocculation - The final rapid mix and flocculation basin design should be based on the pilot plant or in-plant demonstration studies augmented with applicable portions of Sections 5.1. *Rapid Mix and Flocculation*.

2. Filtration

    a. The final filter design should be based on the pilot plant or in-plant demonstration studies augmented by applicable portions of Section 5.2.
    b. Surface wash shall be provided for the filters in accordance with Sections 5.2. *Surface Wash Facilities* or *Air Scouring*.

3. Control and Operation

    a. A continuous recording turbidimeter should be installed on each filter effluent line and on the combined filter effluent line.
    b. Additional continuous monitoring equipment may be required by the Department.
    c. Provisions of Sections 5.2, *Backwash, Miscellaneous, and Filter Media* also apply.

4. Siting Requirements - The plant design should allow for the installation of conventional sedimentation basins when are necessary.

Ultrafiltration (Uf) And Microfiltration (Mf)

Membrane processes are water conditioning processes by which dissolved minerals, or ions, are removed from water by the use of semi-permeable membranes. Membrane processes can be used to remove excess dissolved solid, a variety of organic contaminants, and, to a lesser extent, radionuclides from drinking water. Membrane processes can be used specifically for the removal of particulate material, including microorganisms such as protozoa (Giardia and Cryptosporidium), bacteria, and viruses. UF and MF are membrane processes, which are considered filtration processes. In applications where the removal of dissolved minerals, total organic carbon (TOC), or trihalomethane (THM) precursors is not critical, UF and MF technology may be appropriate. These membrane processes can effectively remove from solution species such as larger organics, colloids, and microorganisms including viruses, bacteria, and cysts.

The use of this filtration technology shall require a piloting study to demonstrate the adequacy and suitability of this method of filtration for the raw water supply to be treated. The pilot study must take into consideration the quantity and quality of the raw water, the pre-treatment and post-treatment processes, corrosiveness of the finished water, and concentrate disposal.

Materials used in construction of UF or MF treatment processes shall be in conformance with ANSI/NSF Standard 61 (Drinking Water System Components – Health Effects – National Sanitation Foundation).

Raw Water Source

One of the most important aspects of membrane treatment plant selection and design is the source and character of the proposed raw water. The main water quality parameters that affect membrane production are turbidity, total organic carbon (TOC), and algae content. Membrane processes can be used to treat turbid waters but may result in higher operation and maintenance costs and possibly more frequent replacement of some membrane types.

Pre-Treatment

Chlorine and its by-products have often proven to be a major cause of membrane failures. System designers must know the properties of the specific membranes to be used in the system to prevent this type of problem. Pre-treatment should include disinfection.

For applications involving removal of various organics, disinfection by-product precursors, and SOCs, pre-treatment shall include the addition of activated carbon or coagulation, or both. Alum coagulation shall not be used as pre-treatment for UF because the alum will readily foul the membrane.

Design Criteria

1. At least two UF or MF units shall be provided, with each unit capable of meeting the plant’s design capacity. When more than two units are provided, the units shall be capable of meeting the plant’s design capacity with the largest unit removed from service.

2. A maximum thirty-six month membrane life should be assumed until satisfactory on-site data is generated.

3. The design shall include the ability to measure plant flow rate of permeate and concentrate water.

4. All units shall be equipped with a feed water and concentrate pressure gauge. The units should also be equipped with permeate water pressure gauge.

5. Taps for sampling feed (raw) water, permeate, concentrate, and finished water shall be provided.

6. A 90% recovery is recommended.

7. On-line instrumentation for hydraulic and water quality characteristics should be provided for membrane feedwater, permeate, and concentrate.

8. On-line instrumentation should be provided to measure flow, pH, temperature, and conductivity every four hours.

9. Automatic controls should be provided to shut down the system during high effluent turbidities, high pressure differential, or failure of the membrane integrity.

Post-Treatment

For applications in which UF and MF processes are used to directly produce drinking water, post-treatment may include removal of toxic gases, improvement of taste and odor, and protection of the distribution system from corrosion and bacteria growth where necessary.

For pre-treatment applications of UF and MF for Reverse Osmosis (RO), the product water from the UF or MF process may be fed directly to the RO system.

Membrane Cleaning

UF and MF systems should be cleaned periodically to maintain flux levels.

Detailed information concerning the manufacturer's cleaning requirements and types of cleaning chemicals should be submitted to the Department as part of the permit application. Chemicals which may come in contact with the water or affect the quality of the water shall be certified to be in conformance with ANSI/NSF Standard 60 (Drinking Water Treatment Chemicals – Health Effects) or meet the food grade standards of the United States Pharmacopeia.

In addition to routine cleaning, regular flushing of all membrane based systems is recommended.

Reverse Osmosis (RO)

Reverse osmosis is a pressure-driven process that retains virtually all ions and passes water. The pressure applied exceeds the osmotic pressure of the salt solution against a semi-permeable membrane, thereby forcing pure water through the membrane and leaving salts behind. RO units may utilize either spiral wound or hollow fiber membranes. RO units are very effective for seawater desalting, brackish water desalting, and fresh water treatment.

The RO process should not be used to treat waters having a total dissolved solids concentration exceeding 12,000 mg/l for low pressure (400 psi) membranes or 30,000 mg/l for high pressure (1,000 psi) membranes without justification. Detailed information shall be submitted with the permit application concerning required feed water quality and anticipated performance capabilities of the RO process.

Pre-Treatment

Pre-treatment systems should be capable of producing feed water of a quality recommended by the manufacturer of the RO unit. Detailed information, including the manufacturer's feed water requirements, proposed pre-treatment equipment, and evidence that the proposed pre-treatment system is capable of producing the desired feed water quality, shall be included in the permit application. Generally, cartridge filtration immediately prior to the membrane is recommended.

Pre-treatment for groundwaters should include acid and antiscalants to inhibit the formation of scale precipitates.

Pre-treatment for surface waters should include disinfection for micro biological contaminants and some form of coagulation-flocculation and filtration for removal of suspended and colloidal matter. Ultrafiltration (UF) and Microfiltration (MF) processes may be used as pre-treatment to extend membrane life.

Pre-treatment of the feed water shall be provided to remove suspended matter or iron and manganese if the feed water contains 5 NTU or more turbidity or 0.3 mg/l or more of iron and manganese. Adjustment of the feed water pH to 5.5 is recommended when cellulose acetate (spiral wound) modules are used. Softening or pH adjustment is satisfactory pre-treatment for hollow fiber modules.

Where the feed water pH is altered, stabilization of the finished water is mandatory. Stabilization is optional in other cases.

Design Criteria

1. For community water systems, two RO units should be provided with each unit capable of meeting the system's design capacity. For non-community water systems, only one unit is required, provided it is equipped with appropriate lock-out to insure that all water consumed has been properly treated.

2. Appurtenant equipment which should be considered in the design of the RO system includes the following:
   a. A polishing membrane filter (less than or equal to eight microns for hollow fiber modules, or less than or equal to twenty-five microns for spiral wound modules) should be provide before the RO unit. Pressure gauges shall be provided on the upstream and downstream side of the filter. The filter shall be located to facilitate changes of the filtering membrane.

   b. All units shall have feed water and permeate pressure gauges and have the capability to measure flow rates of permeate and concentrate water.

c. Taps for sampling permeate, concentrate, and blended (if practiced) flows should be provided.

d. A conductivity meter shall be provided at each installation. A continuous conductivity meter, if installed, shall be constructed so that it may be disconnected from the piping system for calibration with standard solutions.

e. An in-line turbidity meter should be provided on each stage.

f. A maximum thirty-six month membrane life should be assumed until satisfactory on-site data is generated.

g. An automatic high temperature alarm or cut-off switch shall be provided if the feed water is heated. The maximum temperature setting is generally between 80° -90° F depending on the membrane used.

h. All units should be equipped with alarms or automatic controls to shut down the system during high effluent turbidities, high pressure differential or membrane failure (low pressure differential).

i. Cleaning in place is usually accomplished at lower pressures but at two to three times the normal flow velocity on the concentrate side. Chelating agents as well as citric acid are acceptable provided the unit is adequately flushed following cleaning.

Post-Treatment

Treated effluents from the RO process are usually low in pH and solids, high in carbon dioxide, and normally corrosive. Detailed information shall be submitted with the permit application concerning the anticipated corrosiveness of the product water and the methods proposed for stabilizing this water.

Disinfection of the treated water is not required, unless otherwise determined by the Department.

Bag and Cartridge Filtration

Bag and cartridge filtration technologies are usually designed to meet low flow requirements typically of small non-community water supplies. Bag and cartridge filters can effectively remove particles from water in the size range of *Giardia cyst* (5-10 microns) and *Cryptosporidium* (2-5 microns). For Cryptosporidium removal the following sequence is recommended: a 10 micron (nominal) rated preliminary filter, a 5 micron (nominal) intermediate filter, and a 1 micron (absolute) final filter.

Bag and cartridge filters must be discarded once the particular loading capacity of the filters is expended. The life expectancy of a filter is dependent on many factors, including the quality and volume of water being treated and the type of cartridge. The manufacturer's recommended guidelines for bag and cartridge filters should be closely followed. Bag and cartridge filters are usually pressure type filters consisting of a membrane, fabric or string medium with particle size removal, ranging from 0.2 microns up to 10 microns.

Materials

The materials in contact with the water must not impart undesirable taste, odor, color and/or toxic materials into the water as a result of the presence of toxic constituents in materials of construction.

Systems components such as housing, cartridges, gaskets, and O-rings should be certified for performance with ANSI/NSF Standard 61. The filter housing shall be constructed to withstand a hydrostatic pressure of 125 psi.

Design

1. The source water or pre-treated water should have turbidity less than 5 NTU.

2. Flow rates should be maintained at less than 1 gpm/sq. ft of filter area, preferably 0.5 gpm/sq. ft., to minimize pressure loss and increase efficiency. The flow rate through the bag and cartridge filter must not exceed 20 gpm, unless documentation exists to prove the cartridge filters will meet the requirements for removal of particulates at high flow rates. An automatic fix flow rate control shall be provided as an integral

part of the unit to prevent an influent flow rate in excess of the filtering capabilities at any time during its effective life. A totalizing meter should be provided to record daily flow.

3. When various types of bag or filter cartridges or elements with different purposes and performances are available from the manufacturer, they shall bear differentiating identifications that are easily identified and clearly visible. Such identification shall be explained on the package containing the element or cartridge.

4. Waste connections or outlets, if provided, should be through an air gap of not less than 1 inch. Special attention must be given to prevent cross connection between untreated and treated water.

5. The dispenser spout, faucet, or outlet for treated water shall be designed constructed and located such that when the unit is installed in conformance with the manufacturer's instructions, it is directed downward and readily accessible for use.

6. It is recommended that chlorine or another disinfectant be added at the head of the treatment process to reduce or eliminate the growth of algae, bacteria, etc., on the filters. The impact on disinfection by-product formation should be considered.

7. A filter-to-waste component is required for any pre-treatment pressure sand filters. At the beginning of each filter cycle and/or after every backwash a set amount of water shall be discharged to waste before flow begins into the bag filter.

8. A sampling tap should be provided ahead of any treatment so that a source water sample can be collected.

9. A bag or cartridge filter should be constructed or equipped to preclude operation beyond the effective life of the bag or cartridge filter. This may be accomplished by one of the following means:

   a. The unit becomes inoperable when the effective life of the bag filter or cartridge is reached, or

   b. The unit is provided with an easily visible and readily interpretable means of guiding the operation in determining the effective life of the bag or cartridge.

10. Frequent start and stop operations of the bag and cartridge filter should be avoided. One of the following operations is recommended in order to avoid frequent start stop cycles:

11. Slow opening and closing of valve ahead of the filter to reduce flow surges.
    Reduce the flow through the cartridge filter to as low as possible to lengthen filter run times.

12. Install a recirculating pump that pumps treated water back to the head

of the cartridge filter.

13. A pressure relief valve should be incorporated into the bag and cartridge filter housing.

14. Pressure guages must be provided before and after each bag and cartridge filter to properly monitor system pressure loss.

15. An automatic air release valve should be installed on top of the filter housing.

16. A minimum of two bags or cartridge housings should be provided for water treatment systems that must provide water continuously.

Installation

All units shall be readily accessible for maintenance, service inspection and cleaning. The cartridges, filter elements and other replacements shall be readily removable and easily replaced.

Spare cartridges filter elements and other replacement components are to be provided to allow prompt replacement and / or repair by a qualified person properly instructed in the operation and maintenance of the equipment.

Operation

Complete automation of the water treatment plant is not required. Automation of the treatment plant should be incorporated into the ability of the water system to monitor the finish water quality. It is important that a qualified water operator be available to run the treatment plant.

A plan of action should be in place should the water quality parameters fail to meet EPA standards or the guidelines of the Department.

The filter and the back wash rates shall be monitored so that the prefilters are being used optimally. The bag and cartridge filter must be replaced when a pressure difference of 30 psi or other pressure difference recommended by the manufacturer is observed.

Additional observation of filter runs is required near the end of filter runs.

Maintenance (O-ring replacement) shall be performed in accordance with the manufacturer recommendations.

The following parameters should be monitored.

- Flow rate instantaneous
- Flow rate total
- Operational pressure
- Pressure differential
- Turbidity

5.3 Disinfection

Disinfection is required at all surface supplies and at any groundwater supplies that are of questionable sanitary quality or where filtration is provided. Disinfection is recommended for all water supplies. Facilities treating surface water shall have the capability to monitor and record the disinfectant residual continuously.

Chlorination

Chlorination may be accomplished with liquid chlorine, calcium or sodium hypochlorite, or chlorine gas.

1. Chlorination Equipment

    a. Type - Solution-feed-gas chlorinators or hypochlorite feeders of the positive displacement type must be provided (refer to Section 6.0).

    b. Capacity - The chlorinator capacity shall be such that a free chlorine residual of at least 2 mg/L can be attained in the water after contact time of at least 30 minutes when maximum flow rates coincide with anticipated maximum chlorine demands. The equipment shall be of such design that it will operate accurately over the desired feeding range.

    c. Standby Equipment - Where chlorination is required for protection of the supply, complete standby equipment of sufficient capacity shall be available to replace the largest unit during shutdown. Emergency or standby power shall also be available.

    d. Automatic Proportioning - Automatic proportioning chlorinators will be required where the instantaneous flow rate varies by more than 25% of the average flow rate.

    e. Changeover Equipment - Whenever gas chlorine is used, automatic changeover equipment to switch from one cylinder or bank of cylinders to another cylinder or bank of cylinders must be provided to ensure that unchlorinated water is not allowed into the distribution system.

2. Contact Time and Point of Application

a. At facilities treating surface water:

(1) Provisions should be made for applying chlorine to the raw water, settled water, filtered water, and water entering the distribution system.

(2) To demonstrate that a water supply maintains disinfection conditions which inactivate *Giardia* cysts and viruses, the system must monitor and record the disinfectant(s) used, disinfectant residual(s), disinfectant contact time(s), pH, and water temperature. This data is used to determine if minimum total inactivation requirements of the Surface Water Treatment Rule are being met.

(3) The CT value(s) for a system's disinfection conditions are calculated during peak hourly flow once each day that it is delivering water to its customers.

(4) Residual disinfectant concentration is the concentration of the disinfectant (in mg/L) at a point before or at the first customer.

(5) Contact time in pipelines must be calculated based on plug flow by dividing the internal volume of the pipeline by the peak hourly flow rate through that pipeline.

(6) Contact time within mixing basins, settling basins, storage reservoirs, and any other tankage must be determined by tracer studies or an equivalent method, as determined by the Department. The contact time determined from tracer studies to be used for calculating CT is T10. T10 is the detention time corresponding to the time for which 90% of the water has been in contact with the residual concentration. Guidance for determining contact times for basins is provided in *Appendix C* of the *Guidance Manual for Compliance with the Filtration and Disinfection Requirements for Public Water Systems Using Surface Water Sources*.

b. At filtration facilities treating groundwater, provisions should be made for applying chlorine to water entering the distribution system. Free residual chlorination of an approved level is the required practice.

3. Demonstration of Maintaining a Residual

a. At facilities treating surface water:

(1) A minimum disinfectant residual of 0.2 mg/L entering the distribution system must be maintained.

(2) The disinfectant residual cannot be less than 0.2 mg/L for more than four hours.

(3) A detectable residual must be maintained throughout the distribution system. The residual can be demonstrated through heterotrophic plate count (HPC) sampling.

b. For facilities treating groundwater:

(1) A minimum disinfectant residual of 0.2 mg/L entering the distribution system must be maintained.

(2) Higher disinfectant residuals may be required, depending upon pH, temperature, and other characteristics of water.

(3) Maintenance of a detectable residual in all parts of the distribution system is desirable.

4. Testing Equipment

Disinfectant residual can be measured as total chlorine, combined chlorine, or chlorine dioxide (or HPC level). Several test methods can be used to test for chlorine residual in the water, including amperometric titration; n,n-diethyl-p-phenylene-diamine (DPD) colorometric; DPD ferrous titrimetric method; and iodometric method, as described in the current edition of Standard Methods for the Examination of Water and Wastewater.

Equipment shall be provided and should be capable of measuring residuals to the nearest 0.1 mg/L in the range below 0.5 mg/L, to the nearest 0.3 mg/L between 0.5 and 1.0 mg/L and to the nearest 0.5 mg/L between 1.0 and 2.0 mg/L provided where the chlorine demand varies appreciably over a short period of time.

5. Chlorination Piping

The piping system for the injection of chlorine into the water should be of suitable material and should be as direct as possible. An installation whereby chlorine may be applied to the water from each unit independently is much preferred. However, under special conditions, the chlorinators may be manifolded together and a single line run to the point of injection. If only one line is run from the chlorinators to the point of injection, an extra corporation cock should be installed for emergency use.

6. Housing

Adequate housing must be provided for the chlorination equipment and for storing the chlorine (refer to Section 6.0).

Chloramination

Chloramines are a much weaker oxidant than free chlorine, chlorine dioxide, or ozone and are not recommended as a primary disinfectant. When using chloramination as a secondary disinfectant, the following shall apply:

1. Unless specifically approved by the Department, chlorine shall be added and thoroughly mixed in the water prior to the addition of ammonia.

2. Ammonia must be stored in a separate room that is sealed, provided with a shatter-resistant inspection window, and equipped with a door, opening outward, with panic hardware.

3. To assure that ammonia is properly stored, the containment system must include, at a minimum:

   a. A ventilation system that bring fresh air into the room at floor level and exhausts the air from the ceiling to the outside (above grade and away from the fresh air inlet).

   b. A means of shielding the containers from mechanical disturbance or contact with moving objects.

   c. A ventilation fan capable of providing one complete air change per minute.

   d. Separate fan and light switches, which should be located outside the room and at the inspection window.

4. Water systems using chloramines as the terminal disinfectant should advise area hospitals, health clinics, and the local board of health yearly of the presence of monochloramine in the tap water. Notification should be made directly and by public notice. Patients on kidney dialysis machines may be particularly affected.

5. Where chloramination is required for protection of the supply, complete standby equipment of sufficient capacity shall to available to replace the largest unit during shutdown. Emergency or standby power shall also be available.

Ozonation

1. General

   Ozone treatment systems may be used as a predisinfectant and as flocculation enhancement for water treatment facilities using surface water supplies. Piloting evaluations are required to determine ozone effectiveness and sizing for the proposed water treatment facility equipment. Bench testing may be used to determine initial ozone production requirements. Ozone piloting may be used in the pilot process or by contractor columns, based upon Department determinations. The time frame for piloting of ozone treatment systems shall be the same as that approved for water treatment evaluations.

Piloting evaluations should address the following:

a. The required contact time of ozone for maximum disinfection during periods of high algal and bacteriological content. EPA's *Surface Water Treatment Rule Guidance Manual* shall be consulted for determining contact time values. The ozone decay rate for various application points shall also be evaluated.

b. The effects of micro-flocculation from ozone on the treatment process (i.e., filter loading, flocculation, and settling characteristic changes). This evaluation shall include effects on disinfection by-products, filter turbidity effluent, and coagulant dose levels.

c. Ozonation effects on constituents present in the raw water such as color, iron and manganese, volatile organic compounds, and organics (pesticides).

d. Potential health effects of escaping ozone.

e. Corrosive effects of excess oxygen on facility internal piping.

f. Emergency power generator sizing due to ozone equipment addition.

g. Required ozone feed rate in milligrams per liter (mg/L). Maximum required gas application rates will be determined during time periods with the least desirable water quality.

h. The feasibility and design requirements for applying ozone at other points in the treatment process.

i. The most appropriate application points. Ozone may be applied at one point or at multiple points in the process.

2. Ozonation Equipment

a. Facilities using ozonation should be designed to house all ozonation equipment in a separate room and to provide access for unit maintenance.

b. The ozone treatment system shall be sized to provide sufficient capacity to provide a minimum dosage rate of 1.5 mg/L for the required flow, unless piloting confirms a lesser rate.

c. The application of ozone shall take place in a pretreatment contact tank, sized to provide the maximum required CT, as determined by piloting. Chambers shall consist of two dissolution chambers and a reaction chamber. A minimum of 2 feet of free clearance between the bottom of the chamber cover and the baffle wall shall be included. Gas will be placed in the contactor by fine bubble diffusors or by turbine dissolution.

d. Chambers will be designed to provide a contact time of a minimum of 10 minutes at facility design flow. If iron and manganese oxidation is the primary purpose of ozone use, two chambers may be acceptable.

e. Chambers shall have gasketed stainless steel access hatches for periodic inspection, available lighting for operator inspection, and designed with see-through windows for bubbling inspection by operators.

f. Air preparation equipment shall be designed to minimize humidity during worst-case conditions. To ensure optimization of ozone generation and protection of equipment in all cases, design of air preparation equipment will include lowering the operating dew point to -60° C or lower. As a minimum, two towers will be provided to be included in the air-drying process.

g. Flow of ozone gas to each chamber shall be by manual flow control valves. Excess and unused ozone gas shall be directed to a gas destruction system. The ozone gas destruction shall discharge to the atmosphere through a blower and vent stack system.

3. Equipment Design

Equipment shall be provided to meet existing design standards for application of this chemical and to ensure that adequate duplication is provided. Ozone gas preparation systems shall be designed to provide either low, medium, or high pressure delivery systems. Heat generated in the gas stream during compression will be required to be within parameters determined by the manufacturer, with use of an aftercooler, if required.

Typical equipment to be provided with any ozone treatment system includes the following:

a. Air compressor using constant speed motors with excess capacity. Duplication may be required, due to the importance of this unit in the ozone distribution process.

b. Refrigerated air dryers with condensed water drains with excess capacity. Units shall be sized to handle maximum humidity conditions during worst-case summer periods.

c. Desiccant-bed air dryers, used as the final air preparation system, shall be designed to handle maximum dew point conditions from the refrigerated air dryers at the maximum.

d. Dry-air filters sized to meet maximum humidity conditions.

e. Ozone generator with sufficient replacement tubes to ensure continued operation.

f. Ozone diffusion equipment for each application point within the stages of the contact chambers.

g. Off-gas, heat-assisted thermal/catalyst destruction unit and blowers.

h. Main control panel and necessary air control instrumentation, including
   (1) Temperature-sensing indicators for inlet/outlet lines
   (2) Pressure-sensing indicators and transmitters for inlet/outlet lines
   (3) Vibration switches
   (4) Level and flow indicators
   (5) Alarm systems for high inlet pressure, high outlet cooling water, and low cooling water flow

i. Ozone concentration analyzer(s) and necessary laboratory equipment to determine ozone content in the feed stream, off-gas, and contact chamber.

j. Spare parts for each component, including a complete set of dielectric tubes for at least one ozone generator.

4. Safety and Training

a. Approval of ozonation treatment systems by the Department shall be contingent on the public water supplier providing a written plan, outlining classroom and training instruction for personnel, on the ozone treatment system operation. The plan shall provide for training of operation and maintenance for the proposed ozone treatment plant prior to start-up.

b. Safety equipment shall be provided, as required by the manufacturer and the local fire department.

c. Safety equipment shall consist of two ambient low-concentration ultraviolet absorption ozone photometer analyzers within the separate ozone building and at the contact chamber to measure atmospheric air. Gas masks and pressure-demand tanks shall be provided, along with hand-operated gas detector devices.

d. Large signs indicating the presence of an irritant gas shall be located at all entrances to the ozone building.

e. Exhaust of ozone gas, after the ozone destruct unit, shall be below the accepted 8-hour exposure level, at a point away from all building entrances. OSHA and Industry standards shall be consulted for acceptable exhaust levels. Appropriate warning signs shall be placed at the exhaust point.

f. Emergency exhaust fans must be provided in the room containing the ozone generators to remove ozone gas if leakage occurs.

5. Laboratory Equipment

The laboratory shall be specifically equipped with the necessary equipment for the operator to test and sample waters containing ozone gas. Sampling equipment shall be stainless steel, as required. Laboratory equipment shall consist of air sample diaphragm pumps, gas-washing bottles and absorbers, wet-test gas meters, a wall-mounted barometer, and equipment required for ozone determination as outlined in the latest edition of *Standard Methods for the Examination of Water and Wastewater.*

Chlorine Dioxide

1. Chlorine Dioxide Equipment

Chlorine dioxide equipment is similar to chlorine equipment. However, chlorine dioxide is produced in a chemically controlled manner on site due to its explosive nature.

a. The following pieces of equipment are required for chlorine dioxide generation:

(1) Reactor (Pyrex glass)
(2) Diaphragm metering pump
(3) Solution tank
(4) Mixer
(5) Chlorine dioxide generating tower
(6) Electrical controls, as needed
(7) PVC/Tygon and/or polyethylene piping

b. To prevent periods without disinfection or inadequate disinfection, automatic change-over equipment is necessary to switch chlorine gas supply as well as any of the associated reactants in use.

c. Chlorine dioxide may be tested by using the DPD or amperometric methods of analysis.

d. Where chlorine dioxide is required for protection of the supply, complete standby equipment of sufficient capacity shall be available to replace the largest unit during shutdown. Emergency power shall also be available.

2. On-Site Generation of Chlorine Dioxide

a. In liquid media, chlorine dioxide's production involves either of the following reactants:

(1) Chlorine and sodium chlorite
(2) Chlorite and hydrochloric acid

b. In gas phase generation, chlorine gas reacts with liquid sodium chlorite under vacuum. Chlorine dioxide is then removed by a gas ejector.

3. Dosage

The typical dosage of chlorine dioxide in drinking water varies from 0.1 mg/L to 0.5 mg/L, with a maximum of 0.8 mg/L as ClO_2.

4. Safety

Chlorine dioxide should be handled similarly to chlorine. The following precautions should be followed:

a. In the event of an emergency, use self-contained breathing apparatus.

b. Chlorine dioxide cellular detectors should be installed in the area for continuous monitoring of chlorine dioxide leaks, if any. The drawtube of the equipment should be placed close to the floor.

c. Chlorine dioxide mixtures should not be greater than 5%.

d. Due to the corrosive nature of sodium chlorite, the explosive nature of chlorine dioxide, and the fact that chlorine supports combustion in the event of a chlorine gas explosion, the chlorine dioxide facility (particularly the reactors) should be isolated from the rest of the facility, including supportive chlorinators.

e. The storage room should be adequately ventilated. Upon opening the door of the storage room, the exhaust fan should be automatically energized.

f. Chlorine dioxide leak detection equipment should be tested periodically for proper functioning.

g. Ammonia gas can be used to detect chlorine.

h. A formal safety program should be in place for personnel.

Ultraviolet Disinfection

Ultraviolet (UV) light produced by UV lamps has been shown to be an effective bactericide for certain pathogenic bacteria. However, the Department does not consider the use of UV, as specified below, acceptable for the inactivation of *Giardia lamblia* or *Cryptosporidium.* The use of UV cannot be used as a primary disinfectant to meet the requirements of the Surface Water Treatment Rule.

These criteria are for closed vessel reactors, which have the flow parallel to the lamps and use low pressure mercury vapor UV lamps.

Water Quality

1. UV disinfection effectiveness can be impacted by certain water quality parameters. At a minimum, the water to be disinfected must be analyzed for the following:
   a. Iron
   b. Turbidity
   c. Hardness (as $CaCO_3$)
   d. Hydrogen sulfide
   e. Manganese
   f. Suspended solids

2. Based upon the water quality analysis the UV unit shall be capable of providing the proper disinfection at all times. (see Chapter 1, *Design Criteria/Specifications*).
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Materials

1. The materials exposed to UV irradiation and in contact with water shall be formulated to resist deterioration. They shall not impart undesirable taste, odor, color, and/or toxic materials into the water as a result of the presence of toxic constituents in materials of construction or as a result of physical or chemical changes resulting from exposure from UV energy.

2. Systems and/or components shall be constructed of materials suitable to withstand temperatures generated during sustained periods when the unit is not in use.

Design Criteria

1. The UV unit must emit radiation energy in the wavelength range of 245 to 285 nanometers.

2. A minimum UV dosage of 30,000 microwatt-seconds per square centimeter must be achieved by the unit, at the manufacturer's specified *end of lamp life*. This minimum dosage must be applied throughout the reaction chamber.

3. A manufacturer's statement of the percent UV intensity at the *end of lamp life*, as measured by the intensity meter, shall be provided.

4. The UV unit shall be designed to provide the specified minimum dosage at the peak instantaneous flow rate to be expected through the unit. Automatic flow control devices may be required by the Department to ensure that the maximum design flow rate is not exceeded.

5. The UV unit shall be equipped with a minimum of two UV sensors to detect any drop in UV intensity. The UV sensors shall meet the following criteria:

   a. Shall be installed in the wall of the disinfection chamber at the point of greatest distance from the lamps
   b. Shall be provided with documentation that demonstrates that the sensors are stable under conditions typical for that of the proposed unit.
   c. Shall continuously sense the UV intensity produced by the lamps and be provided with a unit mounted intensity meter, which shall display the average percent intensity based upon the Point Source Summation (PSS) method.
   d. Sensors and intensity meter shall be properly calibrated to account for lamp geometry.

6. The UV unit shall be fully enclosed. No open channel units shall be allowed.

7. The UV unit shall be designed to work within the water pressure ranges expected.

8. The UV system shall be provided with ground fault interrupt circuitry.

9. UV disinfection contact chambers should be designed as to prevent short-circuiting.

10. The UV lamps shall be enclosed in quartz sleeves in order to maintain the lamp surface near its optimum operating temperature.

11. UV lamp assemblies shall be insulated from direct contact with the influent water.

12. The UV reactor shall be designed to permit either mechanical or physical cleaning of the quartz sleeve.

13. The unit shall be provided with an elapsed time meter, which accurately monitors the hours that the lamp is on.

14. A flow diversion valve or automatic shut-off valve is to be installed which permits flow into the potable water system only when at least the minimum UV dosage is applied. When power is not being supplied to the unit, the valve should be in a closed (fail-safe) position, which prevents the flow of water into the potable water system.
15. The UV system shall be equipped with a properly sized flow meter in order to monitor the volume of water treated.

16. The unit shall be provided with an audible alarm set to go off and trigger unit shut-down during the following scenarios:

    a. the UV intensity monitor indicates that insufficient UV light, as specified by the manufacturer, is reaching the sensor
    b. lamp failure
    c. the hour meter indicates that the useful life of the bulb, as recommended by the manufacturer, has expired

17. An early warning alarm shall be provided, for both the intensity meter and hour meter, to notify the operator when either the minimum dosage or the useful life of the bulb is within 10% of the levels recommended by the manufacturer. This alarm is not required to shut the system down.

18. The ballast shall operate at a temperature less than 60^{o}C as to prevent premature failure. It shall be UL approved and have a waterproof enclosure located in a remote location.

19. In situations where gravity flow through the unit exists, the system must either have provisions for automatic emergency power or automatic flow shut down in the event of power failure.

20. If UV is the only form of disinfection used in a community system, redundancy may be required by the Department. This secondary or back-up form of disinfection should be on-line and ready for operation if the primary UV unit fails or is taken off-line.

Installation

1. The unit shall be installed in a protected enclosure not subject to extremes of temperature that could cause malfunction.
2. Spare UV tube(s) and other necessary equipment are to be provided to effect prompt repair by qualified personnel properly instructed in the operation and maintenance of the equipment.

3. The unit is to be installed so as to allow ease of access for disassembly, repairs or replacement.

Maintenance

1. An operation and maintenance manual, including a parts list and parts order form, shall be supplied to the owner/operator of the UV unit. The operations and maintenance manual shall be submitted to the Department for approval before the unit goes on-line. The manual shall conform to Policy 93-02 (Operation and Maintenance Manual).

2. At a minimum, the operation and maintenance manual shall address the following:

   a. frequency and procedures for calibrating the intensity meter for proper intensity
   b. frequency and procedures for cleaning sleeves, sensor windows and the interior of the reactor vessel
   c. frequency and procedures for changing lamps, sleeves and sensors
   d. guidance on the proper care and handling of lamps to prevent injury and inadvertent lamp breakage

2. The operation and maintenance manual shall include a separate section that describes the actions required to insure the delivery of treated water in the event of a failure of the UV unit.

5.4 Aeration

Aeration may be used to help remove offensive tastes and odors due to dissolved gases from decomposing organic matter, or to reduce or remove objectionable amounts of carbon dioxide, hydrogen sulphide, etc., and to introduce oxygen to assist in iron and/or manganese removal. The design shall be of a type acceptable to the Department.

Natural Draft Aeration

The design shall provide:

1. For distribution of water uniformly over the top tray

2. Construction of durable material resistant to aggressiveness of the water and dissolved gases

3. Protection from loss of stray water by wind carriage by enclosure with louvers sloped to the inside at an angle of approximately 45 degrees

Forced or Induced Draft Aeration

Devices shall be designed to:

1. Include a blower with a weatherproof motor in a tight housing and screened enclosure.

2. Ensure adequate counter current of air through the enclosed aerator column.
3. Exhaust air directly to the outside atmosphere.

4. Include a down-turned and 24-mesh screened air outlet and inlet.

5. Introduce air in the column that shall be as free from fumes, dust, and dirt as possible.

6. Allow sections of the aerator to be easily reached or removed for maintenance of the interior, or be installed in a separate aerator room.

7. Provide distribution of water uniformly over the top tray.

8. Be of durable material resistant to the aggressiveness of the water and dissolved gases.

Pressure Aeration

Pressure aeration may be used for oxidation purposes only if pilot plant study indicates the method is applicable. Pressure aeration devices shall be designed to:

1. Give thorough mixing of compressed air with water being treated.

2. Provide screened and filtered air, free of fumes, dust, dirt and other contaminants.

Other Methods of Aeration

Other methods of aeration may be used for other treatment needs, such as to remove volatile organic compounds, to remove carbon dioxide for pH control, and to remove radon. Such methods include, but are not restricted to, spraying, diffused air, cascades and mechanical aeration. The treatment process must be designed to meet the particular needs of the water to be treated and subject to the approval of the Department.

Protection of Aerators

All aerators except those discharging to filtration plants shall be protected from contamination from birds and insects.

Disinfection

Groundwater supplies exposed to the atmosphere by aeration must receive chlorination as the minimum additional treatment.

Bypass

A bypass should be provided for all aeration units.

5.5 Iron and Manganese Control

Iron and manganese control, as used herein, refers solely to treatment processes designed specifically for this purpose. The treatment process used will depend upon the character of the raw water. The selection of one or more treatment processes must meet specific local conditions as determined by engineering investigations, including chemical analysis of representative samples of water to be treated, and must receive the approval of the Department. It may be necessary to operate a pilot plant in order to gather all information pertinent to the design. Consideration should be given to adjusting pH of the water to optimize the chemical reaction.

Removal by Oxidation, Detention, and Filtration

1. Oxidation - Oxidation may be by aeration, as indicated on Section 5.4, or by chemical oxidation with chlorine or potassium permanganate or other approved chemical.

2. Detention -

   a. Reaction - A minimum detention of 20 minutes shall be provided following aeration in order to insure that the oxidation reactions are as complete as possible. This minimum detention shall be omitted only where a pilot plant study indicates no need for detention. The detention basin shall be designed as a holding tank with no provisions for sludge collection but with sufficient baffling to prevent short circuits.

   b. Sedimentation - Sedimentation basins shall be provided where chemical coagulation is used to reduce the load on the filters or where indicated by pilot plant study.

3. Filtration - Filters shall be provided and shall conform to Section 5.2.

Removal by Manganese Greensand Filtration

This process is more applicable to the removal of manganese than to the removal of iron.

1. Provisions should be made to apply the permanganate as far ahead of the filter as practical and to a point immediately before the filter.

2. Other oxidizing agents or processes such as chlorination or aeration may be used prior to the permanganate feed to reduce the cost of the chemical.

3. Anthracite media cap of at least 6 inches shall be provided over manganese greensand.

4. Normal filtration rate is 3 gallons per minute per square foot.

5. Normal wash rate is 8 to 10 gallons per minute per square foot.

6. Air washing should be provided.

7. Sample taps shall be provided:

   a. prior to application of permanganate
   b. immediately ahead of filtration
   c. at a point between the anthracite media and the manganese greensand
   d. halfway down the manganese greensand
   e. at the filter effluent

Removal by Ion Exchange

This process of iron and manganese removal should not be used for water containing more than 0.3 mg/L of iron, manganese, or a combination thereof. This process is not acceptable where either the raw water or wash water contains dissolved oxygen.

Sequestration by Phosphates

This process shall not be used when iron, manganese, or a combination thereof exceeds 1.0 mg/L. The total phosphate applied shall be related to the amount of iron and manganese to be sequestered, but in no case to exceed 4 mg/L as PO4, except 10 mg/L may be allowed until the system becomes stabilized as evidenced by presence of 4 mg/L at the extremity of the system. Flushing of the distribution system prior to initial treatment is recommended to accelerate the stabilization.

1. Feeding equipment shall conform to the requirements in Section 6.0.

2. Stock phosphate solution must be kept covered and disinfected by carrying approximately 10 mg/L free chlorine residual in the phosphate barrel. This guideline applies unless it can be shown that the pH or the chemical composition of the phosphate prevents microbiological growth. Chlorine should not be added to the phosphate barrel when the phosphate contains zinc.

3. Polyphosphates shall not be applied ahead of iron and manganese removal treatment. The point of application shall be prior to any aeration, oxidation, or disinfection if no iron or manganese removal treatment is provided.

4. Phosphate chemicals must be food grade and approved by the Department.

5. Plans for the specific installation must be approved by the Department prior to installation.

Sampling Equipment

Smooth-nosed sampling taps shall be provided for control purposes. Taps shall be located on each raw water source, each treatment unit influent and each treatment unit effluent.

Testing Equipment

Testing equipment shall be provided for all plants or arrangements made for testing by a Massachusetts or EPA certified lab as required by the Department.

5.6 Fluoridation

Commercial sodium fluoride, sodium silicofluoride, and hydrofluosilicic acid shall conform to the applicable AWWA standards. The proposed method of fluoride feed must be approved by the Department prior to preparation of final plans and specifications.

Fluoride Compound Storage

Compounds shall be stored in covered or unopened containers and should be stored inside a building. Unsealed storage units for hydrofluosilicic acid should be vented to the atmosphere at a point outside any building.

Chemical Feed Equipment and Methods

In addition to the requirements in Section 6, fluoride feed equipment shall meet the following requirements:

1. Scales or loss-of-weight records shall be provided for dry chemical feeds.

2. Feeders shall be accurate to within 5% of any desired feed rate.

3. To avoid loss of fluoride, the fluoride compound shall not be added before filtration if aluminum coagulants are used. If a clearwell is provided, the fluoride compound should be added to the filter effluent or clearwell effluent for better mixing to guard against overfeeding.

4. The point of application of hydrofluosilicic acid, if into a horizontal pipe, shall be in the lower half of the pipe.

5. A fluoride solution shall be applied by a positive displacement pump having a stroke rate not less than 20 strokes per minute.

6. Adequate anti-siphon devices shall be provided for all fluoride feed lines.

7. The fluoride feeder must be paced in proportion to flow if the flow varies in excess of ± 25% of normal flow.

8. The service water supply shall be metered for sodium fluoride saturators

9. A day tank is required where bulk storage of hydrofluosilicic acid is provided.

10. The water make up line to an upflow saturator must be equipped with a backflow prevention device approved by the Department.

11. If a protected water flush or carry water tee is provided, it must only be teed in on the metering pump discharge line within 10 feet of final fluoride injection point to help avoid slug feeding. An interlock solenoid valve is required.

12. An external saturator overflow prevention system must be installed on the water make-up line to avoid overflows. A non-electrical hydraulic type float valve placed in a fixed six-gallon overflow container is acceptable.

13. The fluoride feeder should be located on a shelf or saturator top not more than 3 feet higher than the saturator or day tank. The suction line be as short as possible. A *flooded* suction line is not recommended in water fluoridation to guard against possible siphoning.

Protective Equipment

At least one pair of rubber gloves, a respirator of a type certified by the National Institute for Occupational Safety and Health for toxic dusts or acid gas (as necessary), an apron, or other protective clothing, and goggles or face masks shall be provided for each operator. Other protective equipment must be provided as necessary.

Dust Control

1. Provision must be made for the transfer of dry fluoride compounds from shipping containers to storage bins or hoppers in such a way as to minimize the quantity of fluoride dust which may enter the room in which the equipment is installed. The enclosure shall be provided with an exhaust fan and dust filter which place the hopper under a negative pressure. Air exhausted from fluoride handling equipment shall discharge through a dust filter to the outside atmosphere of the building.
2. Provision shall be made for disposing of empty bags, drums, or barrels in a manner which will minimize exposure to fluoride dusts. A floor drain or vacuum cleaner shall be provided to facilitate the cleaning of floors.

Testing Equipment

Equipment shall be provided for measuring the quantity of fluoride in the finished water. Such equipment shall be of the specific ion electrode type or approved colorimetric type in compliance with 310 CMR 22.10 and shall be portable.

Plans, Specifications, and Contracts

The Department will review and approve all engineering plans, specifications, and contracts for fluoride feed equipment. Plans and specifications must be submitted by a Massachusetts registered professional engineer. By Memorandum of Understanding with the Massachusetts Department of Public Health (DPH), the Department will allow a DPH engineer to prepare fluoride engineering plans, specifications, and contracts.

5.7 Corrosion Control

Water systems that exceed the lead and/or copper action levels shall install and operate optimal corrosion control treatment in accordance with 310 CMR 22.06B of the Massachusetts Drinking Water Regulations.

Phosphates

The feeding of phosphates may be applicable for corrosion control.

1. Feed equipment shall conform to the requirements in Chapter 6.0.

2. Phosphate must be food grade and approved by the Department.

3. Stock phosphate solution must be kept covered and disinfected by carrying approximately 10 mg/L free chlorine residual in the phosphate barrel. This guideline applies unless it can be shown that the pH or the chemical composition of the phosphate prevents microbiological growth. Chlorine should not be added to the phosphate barrel when the phosphate contains zinc.

Alkali Feed

The feeding of lime, soda ash, sodium hydroxide, potassium hydroxide, sodium bicarbonate, and potassium carbonate may be applicable for adjustment of pH and corrosion control.

Other Treatment

Other treatment for controlling corrosive waters may be used where appropriate. Although sodium is a secondary standard, the public water supplier should evaluate the total sodium level of the water delivered to the customer when considering a corrosion control chemical.

Chemicals that have not been previously used in Massachusetts public drinking water supplies must receive approval from the Department before use.

Control

Laboratory equipment or laboratory service shall be provided to maintain adequate control.

Sampling Equipment

Smooth-nosed sampling taps shall be provided for control purposes. Taps shall be located on each raw water source, each treatment unit influent, and each treatment unit effluent.

5.8 Taste and Odor Control

Provision should be made for the addition of taste and odor control chemicals at all surface water treatment plants. These chemicals should be added sufficiently ahead of other treatment processes to assure contact time for an effective and economical use of the chemicals.

Flexibility

Plants treating water that is known to have taste and odor problems should be provided with equipment that makes several control processes available so that the operator will have flexibility in operation.

Chlorination

Chlorination can be used for the removal of some objectionable odors. Adequate contact time must be provided to complete the chemical reactions involved.

Chlorine Dioxide

Chlorine dioxide has been generally recognized as a treatment for tastes caused by industrial wastes, such as phenols. However, chlorine dioxide can be used in the treatment of any taste and odor that is treatable by an oxidizing compound. When used provisions shall be made for proper storing and handling the sodium chloride, so as to eliminate any danger of explosion.

Powdered Activated Carbon

1. Powdered activated carbon may be added prior to coagulation to provide maximum contact time. Facilities that allow the addition at several points are preferred. Activated carbon should not be applied near the point of chlorine application.

2. The carbon can be used as a pre-mixed slurry or by means of dry-feed machine as long as the carbon is properly wetted.
3. Agitation is necessary to keep the carbon from depositing in the slurry storage tank.

4. Provision shall be made for adequate dust control.

5. The required rate of feed or carbon in a water treatment plant depends upon the tastes and/or odors involved, but provision should be made for adding from 0.1 mg/L to at least 40 mg/L.

Granular Activated Carbon Adsorption Units

Refer to Section 5.2, Filter Media, 11 c.

Copper Sulfate and Other Copper Compounds

Continuous or periodic treatment of water with copper compounds to kill algae or other growths shall be controlled to prevent copper in excess of 1.0 milligrams per liter as copper in the plant effluent or distribution system. Care shall be taken to assure an even distribution. No copper sulfate treatment shall be undertaken without the advice and consent of the Department.

Aeration

Refer to Section 5.4.

Potassium Permanganate

Application of potassium permanganate may be considered, providing the treatment shall be designed so that the products of the reaction are not present in the finished water.

Other Methods

The decision to use any other methods of taste and odor control should be made only after careful laboratory and/or pilot plant tests and on consultation with the Department.

5.9 Waste Handling and Disposal

Provisions must be made for proper disposal of water treatment plant waste such as sanitary, laboratory, facility residuals, and brines. All waste discharges shall be governed by federal and state regulatory agency requirements. The guidelines outlined herein must, therefore, be considered minimum as water pollution control authorities and local authorities may have more stringent requirements. In locating waste disposal facilities, due consideration shall be given to preventing potential contamination of the water supply.

All options for temporary and final disposal shall be evaluated prior to design. The options shall be discussed in a feasibility study that shall determine the most environmentally sound option for the site of consideration. Approval of plans for the treatment facility which uses discharge to a sewer will be dependent upon obtaining approval from the owner of the sewer system, as well as from the Department or the appropriate wastewater permitting authority.

The feasibility study must be done during the pilot study. The design plan will not be approved by the Department until a commitment is made on the facility residuals.

Design of Waste Disposal

The amount of material to be discharged to a sewer system and the authority to do so should be determined prior to the design phase of the facility. The designed waste option should minimize the generation of material by emphasizing reuse, reduction, or recycling of water treatment residuals.

Waste From the Facility

1. Sanitary Waste

   The sanitary waste from water treatment plants, pumping stations, etc., may be discharged directly to a sanitary sewer system, when feasible, or to an on-site disposal facility approved by the Department or the appropriate wastewater permitting authority.

2. Brine Waste

   Brine waste shall be discharged at least 100 feet away from the source of water supply and in a manner approved by the Department or the appropriate wastewater permitting authority.

3. Residuals

   Lagooning may be used as a method of handling residuals. Lagoon size may be calculated using piloting data or know quantities from existing data. Mechanical concentration may be considered. A pilot study is required before the design of a mechanical dewatering installation, unless it can be demonstrated that sufficient information exists to allow the proposed system to be properly designed.

   a. Lagoons - When selected for design, lagoons shall have the following minimum features:

      (1) Be designed with volume 10 times the total quantity of wash water discharged during any 24-hour period.

      (2) Location free from flooding.

(3) Outlet to be at the end opposite the inlet.

(4) Velocity to be dissipated at the inlet end.

(5) Where necessary, dikes, deflecting gutters or other means of diverting surface water so that it does not flow into the lagoon.

(6) A minimum usable depth of 5 feet.

(7) Adequate freeboard.

(8) Adjustable weirs for decanting.

(9) Effluent sampling point.

(10) Adequate safety provisions, such as fencing.

(11) A minimum of two lagoons.

(12) Accessibility for residual removal (by providing ramps).

(13) Lagoons should be lined if located in the Zone I of a groundwater source or Zone A of a surface water source.

(14) An NPDES permit may be required for the effluent of any lagoon.

(15) A groundwater discharge permit may be required by the Department or appropriate wastewater permitting authority.

Note*:* In addition, suspended solids should be reduced to a level acceptable to Department standards prior to being discharged to a watercourse.

b. Sanitary Sewer Discharge - When residuals are discharged to sanitary sewers, a holding or receiving basin is recommended to allow settling of residuals and for the decanting and reuse of waters.

Final Disposal of Waste Residuals

Final disposal of residuals generated by a water treatment facility may be disposed of by one of the following methods, provided that the appropriate authority obtains the required approvals:

1. Landfill
2. Land application
3. Reuse
4. Incineration
5. Sewage collection system
6. Wastewater facility

Approval of Water Treatment Facilities

Water treatment facilities requiring either a Sewer Connection/Extension Permit or Groundwater Discharge Permit shall not be approved until the Department issues the permit.

6.0 Chemical Application

No chemicals shall be applied to treat drinking waters unless specifically permitted by the Department. Refer to *General Design Considerations, Chapter 2* for additional guidance on chemical application.

Although sodium is regulated as a secondary contaminant, the public water supplier should evaluate the total sodium level of the water delivered to the customer when considering adding an approved water works chemical. Chemicals that have not been previously used in Massachusetts' public drinking water supplies must receive approval from the Department before use.

Plans and Specifications

Plans and specifications shall be submitted for review and approval, as provided for in Section 1, and shall include:

1. Descriptions of feed equipment including maximum and minimum feed ranges
2. Location of feeders, piping layout, and points of application
3. Descriptions of storage and handling facilities
4. Specifications for chemicals to be used
5. Operating and control procedures including proposed application rates
6. Descriptions of testing equipment and procedures

Chemical Application

Chemicals shall be applied to the water at such points and by such means as to:

1. Assure maximum efficiency of treatment
2. Provide maximum safety to consumer
3. Provide maximum safety to operators
4. Assure satisfactory mixing of the chemicals with the water
5. Provide maximum flexibility of operation through various points of application, when appropriate
6. Prevent backflow or back-siphonage

General Equipment Design

The general equipment design shall conform with the following:

1. Feeders will be able to supply, at all times, the necessary amounts of chemicals at an accurate rate, throughout the range of feed

2. Chemical-contact materials and surfaces are resistant to the aggressiveness of the chemical solution

3. Corrosive chemicals are introduced in such a manner as to minimize potential for corrosion

4. Chemicals that are incompatible are not fed, stored or handled together

6.1 Facility Design

Number of Feeders

1. Chemical feed systems, when provided, shall include a minimum of two feeders. The standby unit or a combination of units of sufficient capacity should be available to replace the largest unit during shutdown.

2. A separate feeder system shall be used for each chemical applied.

3. Spare parts shall be available for all feeders to replace parts which are subject to wear and damage.

Control of Feeders

1. Feeders may be manually or automatically controlled, with automatic controls being designed so as to allow override by manual controls.

2. Chemical feed rates shall be proportional to flow.

3. A means to measure water flow must be provided.

4. Provisions shall be made for measuring the quantities of chemicals used.

5. Chemical feeders shall be synchronized to start and stop with the flow of water being treated.

6. Process must be manually started following shutdown.

7. Weighing scales.

   a. Shall be provided for weighing cylinders, at all plants using chlorine gas
   b. Are required when hydrofluosilicic acid is used
   c. Should be accurate to measure increments of 0.5% of load

Dry Chemical Feeders

Dry chemical feeders shall:

1. Measure chemicals volumetrically or gravimetrically

2. Provide adequate solution water and agitation of the chemical in the solution tank

3. Provide gravity feed from solution tanks, if possible

4. Completely enclose chemicals to prevent emission of dust to the operation room

Positive Displacement Solution Pumps

Positive displacement type solution feed pumps should be used to feed liquid chemicals, but shall not be used to feed chemical slurries.

Liquid Chemical Feeders: Siphon Control

To prevent chemical solutions from being siphoned into the water supply, liquid chemical feeders shall provide:

1. Discharge at a point of positive pressure, or

2. Vacuum relief, or

3. A suitable air gap, or

4. Other suitable means or combinations as necessary.

Cross Connection Control

Cross connection control must be provided in accordance with the regulations of the Department (310 CMR 22.22).

Location of Chemical Feed Equipment

Chemical feed equipment should be:

1. Located in a separate room to reduce hazards and dust problems

2. Conveniently located near points of application to minimize length of feed lines

3. Readily accessible for servicing, repair, and observation of operation

4. Located either above or inside the containment area

Service Water Supply

Service water supply shall be:

1. Ample in quantity and adequate in pressure

2. Provided with a means for measurement when preparing specific solution concentrations by dilution

3. Softened if hardness exceeds 50 mg/L for NaF saturator and NaF dry feeder

4. Properly protected against backflow

Storage of Chemicals

1. Space should be provided for:

   a. At least 30 days of chemical supply at average flow
   b. Convenient and efficient handling of chemicals
   c. Dry storage conditions

2. Storage tanks and pipelines for liquid chemicals shall be specific to the chemicals and not for alternates.

3. Chemicals shall be stored in covered or unopened shipping containers, unless the chemical is transferred into an approved covered storage unit.

4. Liquid chemical tanks must:

   a. Have a liquid level indicator
   b. Be properly vented
   c. Have an overflow with a minimum size and capacity equal to the fill pipe
   d. Have a minimum 6-inch curb
   e. Be labeled to designate the chemical contained
   f. Have a drain that discharges to a containment area or holding tank

5. Containment areas:

   a. Chemicals related to water supply treatment may be stored in a bermed area capable of containing 110% of the volume of chemicals.
   b. Containment areas must not have floor drains or sump pumps unless the flow is directed to a separate containment area or tank.
   c. Containment areas should contain a sump or positive change to low area to allow pumpage.
   d. Overflow from chemical storage tanks must discharge to the containment area unless this is not feasible due to the nature of the chemical (*e.g.*, hydrofluosilicic acid).
   e. Chemicals that are not compatible shall be stored separately and shall have separate containment areas.

6. Overflow discharged to the outside of the containment area must do one of the following:

a. Discharge to a holding tank with a minimum volume equal to 25% of the storage tank
b. Discharge to a covered containment area with a minimum volume equal to 25% of the storage tank
c. Have an overflow capacity in the storage tank with a minimum volume equal to 25% of the capacity of the tank and a high-level alarm that will be set at the full level, excluding the overflow volume

Solution Tanks

1. A means that is consistent with the nature of the chemical solution shall be provided in a solution tank to maintain a uniform strength of solution. Continuous agitation shall be provided to maintain slurries in suspension.

2. Two solution tanks of adequate volume may be required for a chemical to assure continuity of supply in servicing a solution tank.

3. Means shall be provided to measure the solution level in the tank.

4. Chemical solutions shall be kept covered. Large tanks with access openings shall have such openings curbed and fitted with tight overhanging covers.

5. Subsurface locations for solution tanks shall:

    a. Be free from sources of possible contamination
    b. Assure positive drainage for ground waters, accumulated water, chemical spills and overflows

6. Overflow pipes, when provided, should:

    a. Be turned downward, with the end screened
    b. Have a free fall discharge
    c. Be located where noticeable

7. Hydrofluosilicic acid storage tanks must be vented to the outside atmosphere, but not through vents in common with day tanks.

8. Each tank shall be provided with a valved drain, protected against backflow in accordance with Cross Connection Regulations and liquid chemical feeders guidance. Solution tanks shall be located so that chemicals from equipment failure, spillage, or accidental drainage shall not enter the water in conduits or treatment or storage basins.

9. Solution tanks shall be properly labeled to designate the chemical contained.

Day Tanks

1. Day tanks may be required where bulk storage of liquid chemical is provided.
2. Day tanks should hold no more than a 30 hour supply.

3. Day tanks shall be scale-mounted, or have a calibrated gauge painted or mounted on the side if liquid level can be observed in a gauge tube or through translucent sidewalls of the tank. In opaque tanks, a gauge rod extending above a reference point at the top of the tank, attached to a float, may be used. The ratio of the area of the tank to its height must be such that unit readings are meaningful in relation to the total amount of chemical fed during a day.

4. Hand pumps may be provided for transfer from a carboy or drum. A tip rack may be used to permit withdrawal into a bucket from a spigot. Where motor- driven transfer pumps are provided, a liquid level limit switch and an overflow from the day tank, which will drain by gravity back into the bulk storage tank, should be provided.

5. A means which is consistent with the nature of the chemical solution shall be provided to maintain uniform strength of solution in a day tank. Continuous agitation shall be provided to maintain chemical slurries in suspension.

6. Tanks shall be properly labeled to designate the chemical contained.

Feed Lines

1. Should be as short as possible in length of run, and be:

    a. Of durable, corrosion resistant material,
    b. Easily accessible,
    c. Protected against freezing,
    d. Readily cleanable.

2. Should slope upward from the chemical source to the feeder when conveying gases.

3. Shall be designed consistent with scale-forming or solids depositing properties of the water, chemical, solution or mixture conveyed.

4. Shall be color coded.

Handling

1. Carts, elevators, and other appropriate means shall be provided for lifting chemical containers to minimize excessive lifting by operators.

2. Provisions shall be made for disposing of empty bags, drums or barrels by an approved procedure which will minimize exposure to dust.

3. Provision must be made for the proper transfer of dry chemicals from shipping containers to storage bins or hoppers, in such a way as to minimize the quantity of

   dust which may enter the room in which the equipment is installed. Control should be provided by use of one or more of the following:

   a. Vacuum pneumatic equipment or closed conveyor systems
   b. Facilities for emptying shipping containers in special enclosures
   c. Exhaust fans and dust filters which put the hoppers or bins under negative pressure

4. Provision shall be made for measuring quantities of chemicals used to prepare feed solutions.

Housing

1. Floor surfaces shall be smooth, impervious, slip-proof and well drained.

2. Vents from feeders, storage facilities and equipment exhaust shall discharge to the outside atmosphere above grade and remote from air intakes.

6.2 Chemicals

Shipping Containers

Chemical shipping containers shall be fully labeled to include:

1. Chemical name, purity and concentration

2. Supplier name and address

Specifications

Chemicals shall meet AWWA specifications, where applicable.

Assay

Provisions may be required for assay of chemicals delivered.

6.3 Operator Safety

Ventilation

Special provisions shall be made for ventilation of chlorine feed and storage rooms.

Respiratory Protection Equipment

Respiratory protection equipment that meets the requirements of the AWWA shall be available where chlorine gas is handled, and shall be stored at a convenient location, but not inside any room where chlorine is used or stored. The units shall use compressed air, have at least a 30-minute capacity, and be compatible with or exactly the same as units used by the fire department responsible for the plant.

Chlorine Leak Detection

A bottle of ammonium hydroxide, 56% ammonia solution, shall be available outside the chlorine room for chlorine leak detection; where ton containers are used, a leak repair kit approved by the Chlorine Institute shall be provided. Also recommended is the use of a chlorine gas detector with alarms.

Protective Equipment

1. At least one pair of rubber gloves, a dust respirator for toxic dusts, an apron or other protective clothing, and goggles or face mask shall be provided for each operator as required by the Department.

2. Where caustic soda or other potentially dangerous liquids are stored or handled, safety deluge showers and/or eye baths should be installed between the location of the hazard and the nearest means of egress.

8. Other protective equipment should be provided as necessary.

6.4 Specific Chemicals

Chlorine Gas

1. Chlorine gas feed and storage shall be enclosed and separated from other operating areas. In all installations using chlorine gas, the installation shall be as vandalproof as possible. The chlorine room shall be:

   a. Provided with a shatter resistant inspection window installed in an interior wall
   b. Constructed in such a manner that all openings between the chlorine room and the remainder of the plant are sealed

   c. Provided with doors assuring ready means of exit and opening only to the building exterior

2. Full and empty cylinders of chlorine gas should be:

   a. Isolated from operating areas
   b. Restrained in position to prevent upset
   c. Stored in rooms separate from ammonia storage
   d. Stored in areas not in direct sunlight or exposed to excessive heat

3. When chlorine gas is used, the room shall be constructed to provide the following:

   a. Each room shall have a ventilating fan with a capacity which provides at least 20 complete air changes per hour when the room is occupied.
   b. Exhaust ports for the discharge of air shall be near the floor, as far as practical from the door and air inlet, with the point of discharge so located as not to contaminate air inlets to any rooms or structures.
   c. Air inlets should be through louvers near the ceiling.
   d. Switches for fans and lights shall be outside of the room, at the entrance. A signal light indicating fan operation should be provided at each entrance when the fan can be controlled from more than one point.
   e. Vents from feeders and storage shall discharge to the outside atmosphere, above grade.

4. Chlorinator rooms should be heated to 60 F, and be protected from excessive heat. Cylinders and gas lines should be protected from temperatures above that of the feed equipment.

5. Chlorine feed lines shall not carry chlorine gas beyond the chlorinator room. All piping carrying chlorine gas shall be kept as short as possible.

Acids

1. Acids shall be kept in closed acid-resistant shipping containers or storage units.

2. Acids shall not be handled in open vessels, but should be pumped in undiluted form from original containers through suitable hose, either to the point of treatment or to a covered day tank.

7.0 Pumping Facilities

Pumping facilities shall be designed to maintain the sanitary quality of pumped water. Subsurface pits or pump rooms and inaccessible installations should be avoided.

7.1 Location and Site Protection

The pumping station shall be so located that the proposed site will meet the requirements for sanitary protection of water quality, hydraulics of the system and protection against interruption of service by fire, flood or any other hazard.

The station shall be:

1. Elevated to a minimum of one foot above the highest recorded flood elevation, or protected to such elevation

2. Readily accessible at all times unless permitted to be out of service for the period of inaccessibility

3. Graded around the station so as to lead surface drainage away from the station

4. Protected to prevent vandalism and entrance by unauthorized persons or animals

7.2 Pumping Stations

General

Both raw and finished water pumping stations shall:

1. Have adequate space for the safe servicing of all equipment

2. Be of durable construction, fire and weather resistant and with outward-opening doors

3. Have floor elevation at least 6 inches above finished grade

4. Have underground structure waterproofed

5. Provide a suitable outlet for drainage from pump glands without discharging onto the floor

Suction Wells

Suction wells shall:

1. Be watertight

2. Have floors sloped to permit removal of water and entrained solids

3. Be covered or otherwise protected against contamination

Equipment Servicing

Pump stations shall be provided with:

1. Crane-ways, hoist beams, eyebolts, or other adequate facilities for servicing or removal of pumps, motors or other heavy equipment

2. Openings in floors, roofs or wherever else needed for removal of heavy or bulky equipment

3. A convenient tool board, or other facilities as needed, for proper maintenance of the equipment

Stairways and Ladders

Stairways or ladders shall:

1. Be provided between all floors, and in pits or compartments that must be entered

2. Have handrails on both sides, and treads of non-slip material; stairs are preferred in areas where there is frequent traffic or where supplies are transported by hand

Heating

Provisions shall be made for adequate heating for:

1. The comfort of the operator

2. The safe and efficient operation of the equipment; in pump houses not occupied by personnel, sufficient heat provided to prevent freezing of equipment or treatment process

Ventilation

Ventilation shall conform to existing local and/or state codes. Adequate ventilation shall be provided for all pumping stations. Forced ventilation shall be provided for:

1. All rooms, compartments, pits and other enclosures, where equipment and materials may be damaged

2. Any area where an unsafe atmosphere may develop or where excessive heat may be built up

Dehumidification

In areas where excess moisture could cause hazards to safety or damage to equipment, means for dehumidification should be provided.

Lighting

The pump station shall be adequately lighted throughout. All electrical work shall conform to the requirements of relevant state and/or local codes.

Contingency Planning

Posted in a readily visible part of the pump house shall be a contingency planning sheet containing directions, contacts, and phone numbers of the proper persons to contact in case of emergency. At a minimum, the following phone numbers shall be visible:

1. Police and fire chief
2. Water superintendent
3. Water commissioners
4. The Department’s Regional Office Drinking Water Program point of contact
5. Ambulance service
6. Closest hospital
7. Consulting engineer or geologist
8. Pump manufacturer

Sanitary and Other Conveniences

Except in the cases of small automatic stations or where such facilities are otherwise available, all pumping stations should be provided with potable water, lavatory and toilet facilities. Plumbing must be so installed as to prevent contamination of a public water supply. Wastes shall be discharged in accordance with Section *Waste Handling and Disposal.*

Floor Drains

Floor drains leading to injection wells may route hazardous discharges to the ground. To minimize the threat of a release of hazardous materials or pollutants via floor drains in water supply pump houses, the following criteria will apply:

1. Best Management Practices - The Department requires the following "BMPs":

    a. Absolutely no potential contaminants unrelated to the water supply treatment or distribution system (*e.g.*, oil and paint) may be stored in the pump house.
    b. Water supply treatment related chemicals may be stored in the pump house in a bermed area (capable of containing 110% of the volume of chemicals) as far from the floor drain as is practical.
    c. The immediate area surrounding any pumps or engines that require periodic oil changes must also be bermed.
    d. Any drain(s) should be temporarily but securely covered/isolated during any work (*e.g.*, oil changes) that uses potential contaminants.
    e. Existing MDC traps connected to a floor drain must be strictly maintained and cleaned.
    f. Floors should be cleaned and spills of potential contaminants managed and disposed of using dry cleanup methods.

2. Floor Drain Requirements - Sinks and floor drains may discharge "clean water" (*e.g.*, water from sample sinks, non-contact cooling water, condensate from pipes) to:

    a. A drywell or surface stone outfall (if possible) at least 100 feet from the water supply.
    b. A municipal sewer line outside of the Zone I.
    c. A pump house operating with a sump pump and/or an emergency water cooling system may plumb these systems independently to a drywell or surface stone outfall (if possible) at least 100 feet from the water supply or a municipal sewer line outside of the Zone I.

3. Discharge Plan - Any facility altering a plumbing system currently discharging to the ground must submit a site plan locating all previous points of discharge to the ground and showing the locations and construction of the proposed new discharge.

7.3 Pumps

General

At least two pumping units shall be provided. With any pump out of service, the remaining pump or pumps shall be capable of providing the maximum daily pumping demand of the system. The pumping units shall:

1. Have ample capacity to supply the peak demand without dangerous overloading

2. Be driven by a prime mover able to operate against the maximum head and air temperature that may be encountered

3. Have spare parts and tools readily available

Suction Lift

Suction lift shall:

1. Be avoided, if possible
2. Be within allowable limits, preferably less than 15 feet; if suction lift is necessary, provision shall be made for priming the pumps

Priming

Prime water must not be of lesser sanitary quality than that of the water being pumped. Means shall be provided to prevent backsiphonage. When an air-operated ejector is used, the screened intake shall draw clean air from a point at least 10 feet above the ground or other source of possible contamination, unless the air is filtered by an apparatus approved by the Department. Vacuum priming may be used.

7.4 Booster Pumps

Location and Controls

Booster pumps shall be located or controlled so that:

1. They will not produce negative pressure in their suction lines
2. The intake pressure shall be at least 20 psi when the pump is in normal operation
3. Automatic cutoff pressure shall be at least 10 psi in the suction line
4. Automatic or remote control devices shall have a range between the start and cutoff pressure which will prevent excessive cycling
5. A bypass is available

In-Line Booster Pumps

In addition to the other requirements of this section, in-line booster pumps shall be accessible for servicing and repairs.

Individual Home Booster Pumps

Individual home booster pumps, where required, shall be approved by the water supplier and shall meet all of the requirements listed above.

7.5 Automatic and Remote Controlled Stations

All automatic stations should be provided with automatic signaling apparatus which will report when the station is out of service. All remote controlled stations shall be electrically operated and controlled and shall have signaling apparatus of proven performance. Installation of electrical equipment shall conform with the applicable state and local electrical codes.

7.6 Appurtenances

Valves

Pumps shall be adequately valved to permit satisfactory operation, maintenance and repair of equipment. Each pump shall have a positive-acting check valve on the discharge side between the pump and the shutoff valve.

Piping

In general, piping shall:

1. Be designed so that the friction losses will be minimized

2. Not be subject to contamination

3. Have watertight joints

4. Be protected against surge or water hammer

5. Have an individual suction line for each pump or the lines shall be manifolded to insure similar hydraulic and operating conditions

Gauges and Meters

Each pump shall have:

1. A standard pressure gauge on its discharge line

2. A compound gauge on its suction line

3. Recording gauges in the larger stations; the station should have indicating, totaling, and recording metering of the total water pumped

Water Seals

Water seals shall not be supplied with water of a lesser sanitary quality than that of the water being pumped. Where pumps are sealed with potable water and are pumping water of lesser sanitary quality, the seal shall be properly protected against backflow.

Controls

Pumps, their prime movers and accessories, shall be controlled in such a manner that they will operate at rated capacity without dangerous overload. Where two or more pumps are installed, provision shall be made for alternation. Provision shall be made to prevent energizing the motor in the event of a backspin cycle. Electrical controls shall be located above grade.

7.7 Power

When power failure would result in cessation of minimum essential services, power supply shall be provided from at least two independent sources, or a standby or an auxiliary source shall be provided.

The use and storage of fuel to power pumps, related distribution equipment and treatment systems within the Zone I shall be discussed. Following is a preferred list of fuels to use:

1. Natural gas, if available, is the most preferred source of fuel.

2. Propane gas is the second most preferred fuel type. It must be stored in approved above or below ground tanks. Above ground tanks must be anchored to a concrete platform with dimensions comparable to the tank size and constructed to below local frost line. Underground propane storage containers must be installed according to the National Fire Protection Association Guidance #58-1989, Section 3.2.3.8 (248 CMR 6.00).

3. Liquid fossil fuels shall only be stored on site if natural gas or propane are not a viable option. Liquid fossil fuel tanks shall be double-walled and constructed above-ground in the pump house and shall be surrounded by an impermeable containment wall of greater capacity than the fuel storage tank. Leak detection devices shall be implaced. If fossil fuel storage within Zone I is proposed, an explanation for why natural gas or propane is inappropriate shall be submitted in writing to the Department's Regional Office.

8.0 Finished Water Storage

The material and designs used for finished water storage structures shall provide stability and durability as well as protect the quality of the stored water. Steel structures shall follow the current AWWA standards concerning steel tanks, standpipes, reservoirs, and elevated tanks wherever they are applicable. Other materials of construction are acceptable when properly designed to meet the requirements of this section.

Sizing

Storage facilities should have sufficient capacity, as determined from engineering studies, to meet domestic demands, and fire flow demands where fire protection is provided.

1. Fire flow requirements established by the appropriate National Board of Fire Underwriters should be satisfied where fire protection is provided.

2. The minimum storage capacity (or equivalent capacity) for systems not providing fire protection shall be equal to the average daily consumption. This requirement may be reduced when the source and treatment facilities have sufficient capacity with standby power capability to meet peak demands of the system.

Location of Ground-Level Reservoirs

1. The bottom of reservoirs and standpipes should be placed at the normal ground surface and shall be above maximum flood level.

2. When the bottom must be below normal ground surface, it shall be placed above the water table. Sewers, drains, standing water, and similar potential sources of contamination must be kept at least 50 feet from the reservoir. Water main pipe, pressure tested in place to 50 psi without leakage, may be used for gravity sewers at distances greater than 20 feet and less than 50 feet.

3. The top of a reservoir shall not be less than 2 feet above normal ground surface. Clearwells may be excepted from this requirement when the total design gives the same protection.

Protection

All finished water storage structures shall have suitable watertight roofs that exclude birds, animals, insects, and excessive dust.

Protection from Trespassers

Fencing, locks on access manholes, and other necessary precautions shall be provided to prevent trespassing, vandalism, and sabotage.

Drains

No drains on a water storage structure may have a direct connection to a sewer or storm drain. Drainage shall be directed to an area where flooding and erosion will not occur.

Overflow

All water storage structures shall be provided with an overflow that is brought down to an elevation between 12 and 24 inches above the ground surface, and discharges over a drainage inlet structure or a splash plate. No overflow may be connected directly to a sewer or storm drain. All overflow pipes shall be located so that any discharge is visible.

1. When an internal overflow pipe is used on elevated tanks, it should be located in the access tube. For vertical drops on other types of storage facilities, the overflow pipe should be located on the outside of the structure.

2. The overflow of a ground-level structure shall open downward and be screened with 24-mesh noncorrodible screen installed within the pipe at a location least susceptible to damage by vandalism.

3. The overflow pipe shall be of sufficient diameter to permit waste in excess of the filling rate.

Access

Finished water storage structures shall be designed with reasonably convenient access to the interior for cleaning and maintenance. Manholes above the waterline:

1. Shall be framed at least 4 inches, and preferably 6 inches, above the surface of the roof at the opening; on ground-level structures, manholes should be elevated 24 to 36 inches above the top or covering sod

2. Shall be fitted with a solid watertight cover which overlaps the framed opening and extends down around the frame at least 2 inches

3. Should be hinged at one side

4. Shall have a locking device

Valve Pit

A valve pit with necessary valves, gauges, and sampling tap to collect a representative sample shall be installed. A corporation cock between tank and valve to allow the injection of chlorine shall be installed.

Vents

Finished water storage structures shall be vented. Overflows shall not be considered as vents. Open construction between the sidewall and roof is not permissible. Vents:

1. Shall prevent the entrance of surface water and rainwater

2. Shall exclude birds and animals

3. Should exclude insects and dust, as much as this function can be made compatible with effective venting, for elevated tanks and standpipes, four-mesh non-corrodible screens may be used

4. Ground-level structures, terminate in an inverted “U” or similar type construction with the opening 24 to 36 inches above the roof or sod and covered with 24-mesh noncorrodible screen installed within the pipe at a location least susceptible to vandalism

Roof and Sidewall

The roof and sidewalls of all structures must be watertight with no openings except properly constructed vents, manholes, overflows, risers, drains, pump mountings, control ports, or piping for inflow and outflow.

1. Any pipes running through the roof or sidewall of a finished water storage structure must be welded, or properly gasketted in metal tanks. In concrete tanks, these pipes shall be connected to standard wall castings which were poured in place during the forming of the concrete. These wall castings should have seepage rings imbedded in the concrete.

2. Openings in a storage structure roof or top, designed to accommodate control apparatus or pump columns, shall be curved and sleeved with proper additional shielding to prevent the access of surface or floor drainage water into the structure.

3. Valves and controls should be located outside the storage structure so that the valve stems and similar projections will not pass through the roof or top of the reservoir.

Roof Drainage

The roof of the storage structure shall be well drained. Downspout pipes shall not enter or pass through the reservoir. Parapets, or similar construction which would tend to hold water and snow on the roof, will not be approved unless adequate waterproofing and drainage are provided.

Safety

The safety of employees must be considered in the design of the storage structure. As a minimum, such matters shall conform to pertinent laws and regulations of the area where the reservoir is constructed.

1. Ladders, ladder guards, balcony railings, and safely located entrance hatches shall be provided where applicable.

2. Elevated tanks with riser pipes over 8 inches in diameter shall have protective bars over the riser openings inside the tank.

3. Railings or handholds shall be provided on elevated tanks where persons must transfer from the access tube to the water compartment.

Freezing

All finished water storage structures and their appurtenances, especially the riser pipes, overflows, and vents, shall be designed to prevent freezing that will interfere with proper functioning.

Internal Catwalk

Every catwalk over finished water in a storage structure shall have a solid floor with raised edges and designed so that shoe scrapings and dirt will not fall into the water.

Silt Stop

The discharge pipes from all reservoirs shall be located in a manner that will prevent the flow of sediment into the distribution system. Removable silt stops should be provided where feasible.

Grading

The area surrounding a ground-level structure shall be graded in a manner that will prevent surface water from standing within 50 feet of the structure.

Painting and/or Cathodic Protection

Proper protection shall be given to metal surfaces using paints or other protective coatings and/or, by cathodic protective devices.

1. Paint systems shall meet appropriate AWWA specification. After proper curing, the coating shall not transfer any substances to the water that will be toxic or cause tastes or odors. The tank shall be flushed, disinfected, filled with water, and sampled for coliform and volatile organic compounds prior to going back into service.

2. Cathodic protection should be designed and installed by competent technical personnel.

Disinfection

Finished water storage structures shall be disinfected after construction, repair or maintenance operations in accordance with current AWWA Standards. Representative samples shall indicate microbiologically satisfactory water before the facility is placed into operation.

Maintenance

The exterior and interior of tank should be cleaned and/or inspected annually by qualified personnel. A thorough structural and coating inspection should be conducted every 5 years.

8.1 Plant Storage

The applicable design standards of Section 8.0 shall be followed for plant storage.

Washer Tanks

Washwater tanks shall be sized, in conjunction with available pump units and finished water storage, to provide the backwash water required by Section 5.2, *Chemical Feed*. Consideration must be given to the backwashing of several filters in rapid succession.

Clearwell

Clearwell storage should be sized, in conjunction with distribution system storage, to relieve the filters from following fluctuations in water use.

1. When finished water storage is used to provide the contact time for chlorine (Section 5.3.Chloramination), special attention must be given to size and baffling.

2. An overflow device should be provided.

Adjacent Compartments

Finished water shall not be stored or conveyed in a compartment adjacent to unsafe water when the two compartments are separated by a single wall.

Basins and Wet-Wells

Receiving basins and pump wet-wells for finished water shall be designed as finished water storage structures.

8.2 Pressure Tanks

Hydropneumatic (pressure) tanks, when provided as the only storage facility, are acceptable only in very small water systems. Hydropneumatic storage is considered primarily as an electrical pump control mechanism and not as true water storage. If a community public water system has a design average day flow of 7,500 gallons per day or greater, ground or elevated storage designed in accordance with Section 8.0. should be provided. Pressure tank storage is not considered for fire protection purposes. Pressure tanks shall meet ASME code requirements or an equivalent requirement of state and local laws and regulations for the construction and installation of unfired pressure vessels.

Location

The tank shall be located above normal ground or floor surface and be completely housed and heated for protection from both physical damage and freezing. Earth mounding over the tank is not recommended.

Sizing

1. The approved yield of each well in a community hydropneumatic system should be at least ten times the design average daily consumption rate. A minimum of two wells must be provided, each with the approved yield of at least ten times the design average daily consumption rate.

2. The capacity of wells and pumps in a non-community system should be sized to meet the peak instantaneous design demand in gallons per minute.

3. The gross volume of a hydropneumatic tank, in gallons, should be at least ten times the capacity of the largest pump, rated in gallons per minute. For example, a 250 gpm pump should have a 2,500 gallon pressure tank. Delivery volume in gallons of water from bladder type hydropneumatic tank(s) should be at least three times the capacity (in GPM) of the largest supplying pump (typical for non-community systems).

4. Sizing of hydropneumatic storage tanks must consider the need for chlorine detention time.

Piping

The tank shall have bypass piping to permit operation of the system while it is being repaired or painted. If more than one tank is utilized, each tank should be able to be isolated separately. Provisions should be provided to maintain system pressure while the tank is out of service.

Appurtenances

1. All pressure tanks (including bladder type) shall provide:

a. A drain
b. A pressure guage
c. An automatic or manual air blow-off
d. A means of adding air
e. A pressure-activated off/on switch to control the supply pump
f. A thermal overload or low water cut-off switch for pump protection

2.. Hydropneumatic tanks shall provide:
a. An access manhole, if size of tank permits
b. A water sight glass
c. The size of the access manhole should be 24 inches in diameter, where practical

8.3 Distribution Storage

The applicable design and maintenance standards of Section 8.0 shall be followed for distribution system storage.

Pressures

The maximum variation between high and low levels in storage structures providing pressure to a distribution system should not exceed 30 feet. The minimum working pressure in the distribution system should be 35 psi and the normal working pressure should be approximately 60 psi. When static pressures exceed 100 psi, pressure reducing devices should be provided on mains in the distribution system.

Drainage

Storage structures which provide pressure directly to the distribution system shall be designed so they can be isolated from the distribution system and drained for cleaning or maintenance without necessitating loss of pressure in the distribution system. The drain shall discharge to the ground surface with no direct connection to a sewer or storm drain.

Level Controls

Adequate controls shall be provided to maintain levels in distribution system storage structures. Level indicating devices should be provided at a central location.

1. Pumps should be controlled from tank levels with the signal transmitted by telemetering equipment when any appreciable head loss occurs in the distribution system between the source and the storage structure.

2. Altitude valves or equivalent controls may be required for a second and subsequent structures on the system.

3. Overflow and low-level warnings or alarms should be located at places in the community where they will be under responsible surveillance 24 hours a day.

9.0 Distribution Systems

In determining if a water treatment, collection, storage or distribution system constitutes a public water system as defined by 310 CMR 22.00, the Department shall use the higher value generated by multiplying the:

1. Number of service connections by 1.6

2. Number of bedrooms by 2.0 (or 3.2 in areas of seasonal use)

In determining the average volume of water necessary to support a particular number of residents, the number of residents shall be multiplied by 100 gallons per day per capita. The average water volume accounts for water used for consumption, food preparation, laundering, bathing, and all other indoor sanitary uses with the exception of filling or maintaining indoor swimming pools.

9.1 Materials

1. Standards - Pipe, fittings, valves and fire hydrants shall conform to the latest standards issued by the AWWA, if such standards exist.

2. Used Materials - Water mains which have been used previously for conveying potable water may be reused provided they meet the above standards and have been thoroughly cleaned and restored practically to their original condition.

3. Joints - Packing and jointing materials used in the joints of pipe shall meet the standards of the AWWA. Pipe having mechanical joints or slip-on joints with rubber gaskets is preferred.

9.2 Water Main Design

The normal working pressure in the distribution system should be approximately 60 psi and not less than 35 psi.

1. Pressure - All water mains, including those not designed to provide fire protection, shall be sized after a hydraulic analysis based on flow demands and pressure requirements. The system shall be designed to maintain a minimum pressure of 20 psi at ground level at all points in the distribution system under all conditions of flow.

2. Diameter - The minimum size of water main for providing fire protection and serving fire hydrants shall be 8-inch diameter. Larger size mains should be provided if necessary to allow the withdrawal of the required fire flow while maintaining the minimum residual pressure specified in 9.1.1.
3. Fire Protection - When fire protection is to be provided, the system should be designed so that fire flows and facilities meet the requirements of the NBFU.

4. Small Mains - Any departure from minimum requirements should be justified by hydraulic analysis and future water use, and be considered only in special circumstances.

5. Hydrants - Water mains not designed to carry fire-flows shall not have fire hydrants connected to them.

6. Dead Ends - Dead ends shall be minimized by looping of all mains whenever practical.

7. Flushing - Where dead-end mains occur, they shall be provided with a fire hydrant if flow and pressure are sufficient, or with an approved flushing hydrant or blow-off for flushing purposes. It is recommended that all distribution systems be flushed twice each year. No flushing device shall be directly connected to any sewer.

8. Water Mains - Water mains that have been removed from service for repairs or maintenance or that continue to show the presence of coliform organisms shall be disinfected in accordance with AWWA standard C-651.

9. Annual Maintenance - The Department recommends annual system-wide flushing and a gate valve exercising program.

9.3 Valves

Sufficient valves shall be provided on water mains so that inconvenience and sanitary hazards will be minimized during repairs. Valves should be located at not more than 500-foot intervals in commercial districts and at not more than one block or 800-foot intervals in other districts.

9.4 Hydrants

1. Location and Spacing - Hydrants should be provided at each street intersection and at intermediate points between intersections as recommended by the NBFU Office. Generally, hydrant spacing may range from 350 to 600 feet depending on the area being served.

2. Valves and Nozzles - Fire hydrants should have a bottom valve size of at least 5 inches, one 4-1/2 inch pumper nozzle and two 2-1/2 inch nozzles.

3. Hydrant Leads - The hydrant lead shall be a minimum of 6 inches in diameter. Auxiliary valves shall be installed in all hydrant leads.

4. Drainage - When drains are plugged, the barrels should be pumped dry during freezing weather. Food grade glycerine may be used as antifreeze. Where hydrant drains are not plugged, a gravel pocket or dry well shall be provided unless the

natural soils will provide adequate drainage. Hydrant drains shall not be connected to or located within 10 feet of sanitary sewers or storm drains.

9.5 Air Relief Valves: Valve, Meter, and Blow-off Chambers

1. Air Relief Valves - At high points in water mains where air can accumulate, provisions shall be made to remove the air by means of hydrants or air relief valves. Automatic air-relief valves shall not be used in situations where flooding of the manhole or chamber may occur.

2. Air Relief Valve Piping - The open end of an air relief pipe from automatic valves shall be extended to at least 1 foot above grade and provided with a screened, downward-facing elbow. The pipe from a manually operated valve should be extended to the top of the pit.

3. Chamber Drainage - Chambers, pits or manholes containing valves, blow-offs, meters, or other such appurtenances to a distribution system shall not be connected directly to any storm drain or sanitary sewer, nor shall blow-offs or relief valves be connected directly to any sewer.

9.6 Installation of Mains

1. Standards - Specifications shall incorporate the provisions of the AWWA standards and/or manufacturer's recommend installation procedures.

2. Bedding - A continuous and uniform bedding shall be provided in the trench for all buried pipe. Backfill material shall be tamped in layers around the pipe and to a sufficient height above the pipe to adequately support and protect the pipe. Stones found in the trench shall be removed for a depth of at least 6 inches below the bottom of the pipe.

3. Cover - All water mains shall be covered with sufficient earth or other insulation to prevent freezing.

4. Blocking - All tees, bends, plugs and hydrants shall be provided with reaction blocking, tie rods or joints designed to prevent movement.

5. Pressure and Leakage Testing - The installed pipe shall be pressure tested and leakage tested in accordance with AWWA Standard C600.

6. Disinfection - All new, cleaned or repaired water mains shall be disinfected in accordance with AWWA Standard C601. The specifications shall include detailed

procedures for the adequate flushing, disinfection, and microbiological testing of all water mains.

7. Chlorinated Discharge - In accordance with AWWA Standard C-651, thorough consideration should be given to the impact of discharge of highly chlorinated water to the environment. If there is any possibility that chlorinated discharge will cause damage to the environment, a neutralizing chemical, as listed in AWWA standard C-651, shall be applied to the water to be wasted to neutralize thoroughly the chlorine residual remaining in the water. Where necessary, federal, state, and local regulatory agencies should be contacted to determine special provisions for the disposal of heavily chlorinated water.

9.7 Separation of Water Mains and Sewers

1. General - The following factors should be considered in providing adequate separation:

    a. Materials and type of joints for water and sewer pipes
    b. Soil conditions
    c. Service and branch connections into the water main and sewer line
    d. Compensating variations in the horizontal and vertical separations
    e. Space for repair and alterations of water and sewer pipes
    f. Off-setting of pipes around manholes

2. Parallel Installation - Water mains shall be laid at least 10 feet horizontally from any existing or proposed sewer. The distance shall be measured edge to edge. In cases where it is not practical to maintain a 10-foot separation, it is permissible to install a water main closer to a sewer. However, the water main must be laid in a separate trench or on an undisturbed earth shelf located on one side of the sewer at such an elevation that the bottom of the water main is at least 18 inches above the top of the sewer.

3. Crossings - Water mains crossing sewers shall be laid to provide a minimum vertical distance of 18 inches between the outside of the water main and the outside of the sewer. It is preferred that the water main cross above the sewer. At crossing, one full length of water pipe shall be located so both joints will be as far from the sewer as possible. Special structural support for the water and sewer pipes may be required, as well as special materials for construction and connecting devices.

4. Sewer Manholes - No water pipe shall pass through or come in contact with any part of a sewer manhole.

9.8 Surface Water Crossings

Surface water crossings, whether over or under water, present special problems.

1. Above-Water Crossings - The pipe shall be adequately supported and anchored, protected from damage and freezing, and accessible for repair or replacement.

2. Underwater Crossings - A minimum cover of 2 feet shall be provided over the pipe. When crossing water courses which are greater than 15 feet in width, the following shall be provided:

    a. The pipe shall be constructed with flexible watertight joints.
    b. Valves shall be provided at both ends of water crossings so that the section can be isolated for testing or repair; the valves shall be easily accessible, and not subject to flooding; the valve closest to the supply source shall be in a manhole.
    c. Permanent taps shall be made on each side of the valve within the manhole to allow insertion of a small meter gauge for testing to determine leakage and for sampling purposes.

9.9 Cross Connections

A cross connection is an interconnection between the potable drinking water line and any connection with non-potable water, gases, or chemicals.

Cross-connection Control Program Plan

Every public water system shall have a cross-connection control program approved by the DEP. A community PWS cross-connection control program must include a program description, staff profile, strategies for testing, surveying, compliance and enforcement, fees structure, all forms required by the state, and a registration and tracking system. Small community PWS, with a population less than 3,300 people, must complete the questionnaire, *Cross-connection Control Program Plan for Small Community Public Water Systems.* Non-community PWS must complete the *Cross-connection Program Plan Questionnaire for Non-community Public Water Systems.*

Cross-Connection Survey

All commercial, industrial and institutional facilities must be surveyed for cross-connections by a public water system. All cross connection surveys must be conducted by a Massachusetts Certified Cross-Connection Surveyor.

Backflow Preventer Devices

1. Backflow prevention devices must be installed by a Massachusetts Certified Plumber, with the exception of devices located on fire protection systems. A Massachusetts Certified Fire Sprinkler Installer must install these particular devices.

2. A Massachusetts Certified Backflow Prevention Device Tester shall do all tests performed on backflow prevention devices.

3. Backflow prevention devices must meet the following installation specifications:

    a. Reduce pressure backflow preventer (RPBP) and double check valve assembly (DCVA) with shut-off;
    b. Backflow prevention devices must be installed in a horizontal alignment between 36 and 48 inches from the floor to the bottom of the device and a minimum of 12 inches from any wall; and
    c. Installation of RPBP and DCVA in a vertical position must be determined by the PWS, considering adequate distances for the testing and maintenance of the devices.

Fire Protection Systems

1. All existing cross-connections between public water systems and fire protection systems, (310 CMR 22.22), installed prior to March 21, 1997, shall be equipped with an UL listed alarm check valve with the standard alarm pressure switch trim package. The device shall comply with regulatory requirements of 310 CMR 22.22(9)(d)6.

2. Fire protection systems installed on or after March 21, 1997, shall be equipped with a protection device as specified at 310 CMR 22.22(9)(d)l. Generally, a backflow prevention device should be installed when the cost (device and installation) is equal to or less than 5% of the total cost of the fire protection system modification; or when the total cost of the system modification (excluding installation costs) equals or exceeds $100,000.

3. A PWS may not approve the installation of a backflow prevention device until a building permit is issued in accordance with 780 CMR, and approved by the local fire department.

Cross-Connection Certification and Renewal

1. Backflow Prevention Device Testers and/or a Cross-Connection Surveyor must pass the respective certification examinations approved by the Department.

2. Cross-connection surveyors must be certified annually. If a surveyor does not apply for a cross-connection certification for more than one year from the original exam date, they must retake the exam.

3. Cross-connection surveyors or testers that have expired certifications (more than one year from the expiration date), must retake the exam, or attend a certification renewal class as approved by the DEP.

Cross-Connection Surveyor Responsibilities

1. Surveys

   a. Inspect all the distribution systems beginning at meter or source until the last tap.
   b. Keep records of findings by using the Cross-connection Survey Report form and Violation Notice available through the Department.
   c. Submit a cross-connection survey report to the facility owner. If the town subcontract the services of a surveyor, the cross-connection survey report must be routed through the PWS before going to the facility owner.
   d. Facility owner is responsible for eliminating or protecting all existing and potential cross-connections within the facility.
   e. The facility owner must submit plans and design data sheet for the installation of backflow prevention devices to the PWS.

2. Plans and Design Data Sheet

   a. Review and approve or deny the plans for the installation of air gap separation.
   b. Letters of approval or denial must be signed the person responsible for the cross connection program at the PWS.
   c. Submit approval letters to the local plumbing inspector; or to the local building inspector and fire marshal for devices on fire protection systems.

Steps

New Facilities -To avoid creating cross connections in new facilities, have the PWS, plumbing inspector, building inspector and fire marshal review the plumbing plans.

Existing Facilities - The facility owner is responsible for the elimination or proper protection of all cross-connections found as a result of a cross-connection survey. All plans for corrective actions of cross-connections that require the installation of a reduced pressure backflow preventer (RPBP) or double check valve assembly (DCVA) must be submitted to the PWS for review and approval. A plumbing permit must be issued for all the other backflow preventer devices. The installation must be done by a license plumber and inspected by the local plumbing inspector. In some cases, other local officials should be involved, such as the fire marshal and/or building inspector.

10.0 Water Management Act Requirements

Editor's note: This chapter, pp. 196 – 225, is being revised and will be available with the 2002 annual update. Refer to *1996 Guidelines and Policies for Public Water Systems* for specific text. Check the DEP Web site: www.state.ma.us/dep.

11.0 Capacity Development and Standard Operation Procedures

This guidance is designed to provide public waters systems with methodologies to establish and maintain the "technical, managerial and financial capacity" to sustain operations as required by the Federal Safe Drinking Water Act. The guidance is intended as a voluntary tool for systems to use as appropriate. Nevertheless, in accordance with MGL Chapter 111 Section 160 the Department may require certain systems in noncompliance to follow particular aspects of this guidance in order to achieve or return to compliance. Not all parts of Chapter 11 are applicable to all systems.

11.1 Synopsis of Capacity Development Process

In accordance with the U.S.EPA guidance on capacity, public water system capacity is the ability of a public water system to plan for, and maintain compliance with applicable federal and state drinking water standards. Capacity has three components: technical, managerial, and financial. Adequate capability in all three areas is necessary for a system to have "capacity". In evaluating system Capacity, the Department requires the demonstration of effective controls in all three areas of Capacity.

In accordance with the U.S.EPA guidance on capacity, public water system capacity Development is the process of a water system acquiring and maintaining adequate technical, managerial, and financial capabilities to enable it to consistently provide safe drinking water.

As part of the Safe Drinking Water Act Amendments of 1996 (SDWA), each state had to submit a Capacity Development Strategy to EPA. The Department's Strategy was submitted and accepted. The Strategy outlined ways in which The Department would work together with water systems to ensure that the PWS acquire and maintain the technical, financial and managerial capacity needed to meet the SDWA public health objectives. The preceding chapters of these guidelines primarily discuss the minimum criteria used by the Department to demonstrate adequate technical capacity. Therefore, this chapter will address the minimum guidelines that demonstrate financial and managerial capacity and delineate the processes that are necessary to plan for, achieve and maintain capacity.

The Department will use the following three processes to assist public water systems to achieve capacity:

1. Education and Technical Assistance– In addition to information on technical issues the Department will provide PWS with financial and managerial reference material, training and technical assistance.

2. Prevention – The Department will provide PWS with capacity guidelines that PWS can use to forestall a technical, financial or managerial breakdown that could result in violation of a drinking water standard, in poor drinking water quality and/or in a public health emergency.

3. Corrective Action – Drinking water records indicate and the Department recognizes the fact that some violations of the Department's "technical" requirements are often the result of a "financial" or "managerial" breakdown. When the Department makes such a determination, it will use these guidelines in conjunction with its Enforcement Strategy to improve the financial and managerial health of the system.

The following managerial and financial capacity guidelines can be used by PWS to enhance its system capacity. Please note that many of these guidelines may not be applicable to all systems, as much of the language is geared to larger systems. However, they may be used by small systems to develop simplified documentation appropriate to their system size.

11.2 Management Capacity

Management capacity is the ability of a water system to operate in compliance with SDWA requirements. It refers to the system's institutional and administrative capabilities - including ownership, accountability, staffing, organization, documentation, and planning. The following items in Section 11.2 are generally used to demonstrate that a PWS has adequate managerial capacity.

11.2.1 Statement of Purpose

Every water system should have a written document that states its primary mission and provides guidance on decision making. It should define: the mission, the customer, and the product standards for safe drinking water, for delivery and for payment process. This written statement of purpose document provides a common basis for management and employees to work together within the organizational structure to meet objectives. Management and employees should be familiar with this document, and it should be reviewed periodically.

11.2.2 Legal Components

11.2.2.1 The Entity

Every public water system should understand what type of legal entity it is; and how that type of entity is required to operate on delivering water. It should keep a copy of its Articles of Incorporation, enabling legislation, or the State Law under which it operates in a safe, permanent file. Each new manager (responsible party, owner, selectmen, board member, supervisor, etc.) should receive a copy of this document. Refer to the *Model Water and Sewer Commission Reorganization Act, Chapter 40N of the Massachusetts General Laws* for guidance on developing an appropriate legal authority for a new or existing water system.

11.2.2.2 Documents and Filings

All court orders, deeds, easements, long term contracts or leases, bylaws, inter-municipal agreements, official maps of the service area, and similar documents should be stored in a permanent file in a safe location that is known to system managers.

11.2.2.3 Authority and Responsibilities

Each manager (responsible party, owner, selectmen, board member, supervisor, etc.) should review the documents that outline the power, authority, duties and responsibilities of management (board of water commissioners, selectmen, supervisors, etc.). PWS should develop an informational package for new management that includes key documents, a map of the system, an organization chart, a rate chart and other information. Managers (responsible party, owner, selectmen, board member, supervisor, etc.) should receive basic training on the duties and responsibilities of managing a PWS.

11.2.2.4 Meeting Records and Minutes

Official actions should be recorded in writing and saved in a record book. Minutes should include votes, any changes to bylaws, and other legal actions of the PWS. This ensures an historical and documented record of actions.

11.2.2.5 Bylaws, Rules and Regulations

Bylaws, rules and regulations of the PWS should be written, and changed only by a recorded vote. These documents should be updated periodically to include amendments and deletions. The cover page should include the effective date and a note on revisions, such as *contains all revisions through 31 October 2001*. Copies of bylaws, rules and regulations should be available to qualified parties upon request. Standard operating procedures (SOPs, as noted below) may be considered as bylaws and/or regulations.

11.2.2.6 Organizational Structure

Each PWS should have a formal Organization Chart that clearly shows the chain of command within that PWS. The chart should start at the highest level (mayor, selectmen, and water commissioners) and include all employees, contract help, and part time staff including primary and secondary operators.

The ownership of the PWS should be clear to the service population, the local community and local, state and federal agencies. Adequate personnel policies should be in place to retain and compensate personnel and to provide appropriate training as needed or recommended.

11.2.2.7 Duties and Responsibilities

A job description should be created for each position on the organization chart.
Job descriptions are an important part of organizing the work within the water system. A job description should define a person’s duties and responsibilities, supervisor, and staff supervised. These may serve as a basis for the person’s salary and duties. In the process

of developing job descriptions, gray areas may be defined, and areas of conflict identified.

11.3 Standard Operation Procedures (SOPs) and Policies

Generally, SOPs and policies are included with the bylaws and regulations of the organization. These should all be **written** documents.

11.3.1 Operational Policy

Management should define the operation and maintenance of the PWS. For example, *Policy Describing the Flushing Program Required by the Department*. If a board oversees the PWS, one board member should be designated as the link between the board and the certified operator in charge of the PWS. The certified operator should file monthly written reports with the board or its designee. The monthly reports should include at a minimum, water quality test results, maintenance performed, and recommendations for improvements.

Manuals for every piece of equipment should be kept in a central location in a bound book or file, and logs should be kept of all repairs and maintenance. There should be a policy that sets the maximum amount of money that the operator may spend without obtaining the board's permission.

11.3.2 Personnel/ Professional Improvement/ Hiring Policy

Each PWS should have a written personnel policy. It should state the holidays and vacation policy, limitations or approvals required for time off and overtime, and operation during emergencies and off-duty time. The process for handling employee grievances should be clearly stated. A written personnel policy is needed to protect the rights of the individual employee and the PWS.

The amount of money involved in sick and vacation time accrued should be recorded and reported to the employee at regular intervals. A dedicated account is recommended for deposit of wages for accrued sick and vacation time.

The PWS commitment to continuing education should be defined in this policy. It should include requirements for professional memberships and training. It should clearly state criteria for training, approval of training requests, payment of fees and mileage, and use of PWS vehicles. All staff should be adequately trained prior to starting their jobs.

For PWS that have a board of water commissioners or a similar structure, the policy should specify the method for filling board vacancies, attendance requirements for commissioners, and training of board members. It should address completing tasks in a timely manner. Policy should include provisions for removing a commissioner from office (e.g., continued absence at meetings). Positions such as the treasurer and superintendent should not be part of the control structure (e.g., board of commissioners) wherever feasible to avoid conflict of interest.

11.3.3 Conflict of Interest Policy

Preventing conflict of interest is an important consideration when organizing work within the water system. Although the state law covers what constitutes a conflict of interest for municipal and district employees, the PWS should have a written policy that defines acceptable and unacceptable activities.

11.3.4 Water Rates Policy

Every PWS should have a written policy on water rates and other charges. At a minimum it should address the following:

- What the rates cover. Does the rate cover capital and operating expenses? Does the PWS receive subsidies or other income sources?
- Rate classifications and how rates are changed.
- An explanation on fees and charges such as seasonal connections, shut-off/ turn-on fees, impact and connection fees, emergency water ban violation fines, and fees for various size services or meters.

The policy should state the rationale for the rate, fee structures, and the procedures for establishing rates. Rate procedures outlined in the enabling legislation for the PWS may be repeated in this policy.

The PWS should have a printed rate card available to all customers and potential customers. It should include all water rates. Often this is printed on the back of the water bill.

Every PWS user should be metered. Each user should receive a water bill based on actual readings (quarterly or more frequent bills are suggested). Parks, public buildings and other community facilities may be exceptions to this quarterly billing rule, but they should be metered and monitored.

The Massachusetts water conservation standards require PWS to develop a 100 % metering program for all public and private users. The PWS operations plan should include regular meter reading of all users.

The PWS should keep an inventory of all its meters and should systematically check meters for accuracy. There should be an active and ongoing program to replace aged and broken meters. Refer to Section 11.5.2.6 for typical useful life of fixed assets. The normal life expectancy of water meters ranges from 7 to 15 years.

11.3.5 Connections and Main Extensions Policy

There should be a written policy outlining conditions for new connections to the water system. The connection policy should include the following:

- The responsibility of the PWS
- The responsibility of the potential customer
- Conditions for the denial of a connection to the system
- The materials and methods to be used when installing the service line
- Method for establishing the fee for connection to the system
- Who owns (and is responsible for repair to) what component of the connection to the main.

In some cases, the PWS will install the service connection and bill the customer for the cost of the installation from the curb cock to the building. In other cases, the potential customer is responsible for installing the service connection. It is important to state the responsibility of the customer in regard to the connection. The PWS should not allow any connections that would result in the system exceeding the safe yield of its sources or the hydraulic capacity of its distribution system.

There should be a written policy regarding the extension of water mains to serve new areas both inside and outside the current service area. Often (if the water main extension is to serve a new housing or industrial development), the developer is required to pay the costs of installing the pipe to the specifications of the water system. If it is desirable to install a larger main than required by the development, the policy should clearly state who pays the difference for the larger sized pipe. The type of pipe, depth, bedding material, and other related specifications should be noted in the policy. The Department also requires a Cross-Connection Control Program Plan (See Chapter 9, *Distribution Systems*).

11.3.6 Water Conservation and Drought Emergency Policy

Each PWS should work with local officials to adopt a drought emergency bylaw or health regulation that authorizes increasingly stringent mandatory water conservation measures with escalating penalties for failure to comply. A *Model Water Use Restriction Bylaw/Ordinance* is available on the Department's web site.

The drought emergency bylaw is only one part of a water conservation policy. The policy should also include the following components:

- "Increasing block rate" pricing or conservation pricing
- Education of users to reduce water use
- A series of increasingly stringent voluntary measures to reduce water use
- Assistance to the largest water users on how to save money by reducing water use
- Reducing the amount of "unaccounted-for" water
- Methods to monitor the success of the program

For more information on water conservation standards, drought and emergency planning, review the following resources:
Water Conservation Standards for the Commonwealth of Massachusetts, the Department's Policy 87-05, Declaration of a Water Supply Emergency, the provisions of

MGL Chapter 40, section 41 A, Water Emergency, Chapter 10 of these Guidelines and the Web sites of AWWA, NEWWA, and the MWRA.

A PWS may impose voluntary water use restrictions at any time without the Department's approval. However, a PWS may not impose a mandatory ban without the Department's approval. A PWS may impose a mandatory ban only if it has a Water Use Restriction Bylaw/Ordinance approved by the Department. The Department can declare a *Declaration of Water Supply Emergency* only after the water system petitions the Department. The Department can attach conditions to the Declaration as required. A Declaration remains in effect for 6 months unless revoked by the Department.

11.3.7 Leak Detection and Unaccounted for Water

Each PWS should adopt a policy for leak detection and tracing of "unaccounted-for" water. All connections, including public buildings, should be metered, (See Section 11.3.4, *Water Rate Policy*). A full leak detection survey of the distribution system should be completed every two years; identified leaks should be repaired within a year. The PWS should calibrate its master meters annually, (at a minimum), to ensure water meter accuracy. There should be a program to replace or rebuild water meters for each connection on a 10-year cycle. The policy should include a requirement that all large quantity water users calibrate their meters each year at their expense.

For a well-run PWS, the amount of unaccounted water should be below 10% of total water consumption, and should remain under 15% at all times. Water systems should monitor tanks and lines for leaks, and implement a leak detection program.

PWS should encourage their customers to conduct on-site leak detection. By reducing the amount of "unaccounted-for" water, the system may:

- Reduce costs of operation by reducing electricity and pumping cost
- Reduce impacts on ground water wells by pumping less
- Delay the need to add another source, add storage, increase pipe sizes, or increase treatment capacity
- Increase the life span of equipment

Note**:** If a new withdrawal or source over 100,000 gallons per day is being considered, the Water Management Act requires careful attention to water conservation with special attention directed at reducing the amount of unaccounted for water. (See Chapter 10, *Water Management Act Requirements*). If a water supply source requires an Interbasin Transfer Act approval, the water conservation plan must meet the *Interbasin Transfer Act Performance Standards* adopted by the Water Resource Commission in 1999.

11.3.8 Service Shut Off and Restoration Policy

Each PWS should have and enforce a delinquent account policy which specifies how past due accounts of water customers will be handled. It is important that this policy be uniformly applied. Many water systems experience cash shortages because customers do not pay their bills. The delinquent account policy sets forth the steps the system will take, and the customer's options. Often the procedure includes a second billing with interest and perhaps a penalty; a third billing with interest and a shut off warning; a final shut off warning; and an onsite visit with a doorknob hanger explaining the shutoff (often the shutoff will leave trickle running for public health purposes); and then shutoff. Some water systems use other methods, such as small claims court. For a district or municipality, a lien may be placed on the property as specified in the MGL Chapter 40 Sections 42A through 42F.

The policy should state in a clear, step-by-step process:

- what constitutes a delinquent (or past due) account
- how the shut-off/turn-on is accomplished
- conditions for restoration of service
- exceptions to the policy

Additional guidance may be found at *MGL Chapter 40N, Section 9(d).* The provisions of *MGL Chapter l65 Sections 11A through 11E* explain the procedure to be used by a private water company for shutting off water.

Note: Privately owned PWS are required to follow the billing and termination policy as listed in the Department of Telecommunications and Energy's (DTE) regulation 320 CMR 25.00. This policy can be used as a model for publicly owned water systems.

11.3.9 Billing Policy

Each PWS should have a written billing policy.
The water billing policy is often included in the rules and regulations or bylaws. The written policy should state:

- Frequency of billing
- Dates when water bills should go out
- Provision for estimating the bill when the meter can not be read
- Provision for handling absentee and seasonal customers
- Procedure a customer follows in contesting the amount billed
- Provisions for deferral of charges as allowed by MGL Chapter 40 Section 42J
- Special policies on the elderly, handicapped, veterans, or other groups
- Procedures for abatements or refunds

Billing should follow shortly after the filing of the meter readers' report. More frequent billing such as quarterly and monthly may make payments easier for customers.
Every water system user should be metered and receive a water bill based on readings. There should be a plan developed to install meters for all non-metered connections. Install outside- meter readers wherever possible.

Note: Privately owned PWS are required to follow the billing and termination policy as listed in the Department of Telecommunications and Energy's (DTE) regulation 320 CMR 25.00. This policy can be used as a model for publicly owned water systems.

11.3.10 Customer Comment Policy

Each PWS should have a written policy regarding complaints, comments and compliments. It should contain:

- A complaint/comment/compliment logbook
- Procedures for PWS to follow up complaints/comments
- Procedures to inform customers of complaints/comments investigation results
- Filing system for information collected and record of resolution

Note: Tracking complaints may seem arduous; however, gathering and reviewing this data may uncover seasonal or intermittent problems with the system that would not have been discovered. Tracking comments may result in system improvements. Tracking compliments will improve staff morale and encourage positive attitudes.

11.3.11 Bidding and Purchasing Policy

Each PWS should develop its own written Bidding and Purchasing Policy so that the steps and procedures are clear and understood by all parties. The policy should cite the contracting agency, and the method of recording and filing quotes and bids. Refer to the *Guide for Local Government Procurement of Supplies, Services and Real Property* that is available from the state bookstore.

District and municipal water systems (and in certain cases, privately owned water systems receiving public grant or loan money) are required to comply with the MGL Chapter 30B *Massachusetts Uniform Procurement Act*; or MGL Chapter 30 *Public Bidding Laws*, especially Section 39M. These laws are fairly complex and in certain circumstances allow several alternative courses of action.

11.3.12 Accounts /Receivable/Payable/Segregation Policy

Each PWS should have a written policy on handling of accounts payable, accounts receivable, and the segregation of duties. This policy should spell out the approval process for routine bills, special provisions for approval of large bills, required paper trail, person responsible for the tasks, filing system, and documentation needed for the bill payment. Note the importance of separating duties to ensure accuracy and honesty. Policy should require bonding of staff responsible for the money.

11.3.13 Bonding and Insurance Policy

Each PWS should have a written policy that sets out the amount of bonding required for officers and employees that handle money and the amount of property damage and liability insurance needed. The water commissioners might wish to have an insurance policy for oversight and omissions. This policy is usually not needed for municipalities that already have such coverage.

11.3.14 Management Information Systems Policy

A management information systems policy outlines procedures for informing managers of the financial and operational status of the system. The management informational system should have a standard periodic report that includes:

- Summary of expenditures by category
- Revenues received by category
- Cash available for paying bills
- Status of delinquent rate payers by age of account
- Status of actual versus budgeted expenses and revenues
- Deviation of year-to-date budget from year-to-date expenses by line item
- Brief outlook for the future

The report should also include an operational summary of accomplishments, complaints and resolution, a summary of short-term, midterm and long-term operational plans, and other matters of interest to management. Develop a standard format for these reports.

11.3.15 Land Management Policy

Each PWS should have a written land management policy that states the public water system's commitment to land management, including:

- Activities that are allowed
- Management philosophy/future plans
- Specific requirements such as forest management plans and maps, wildlife management plans, and watershed management plans
- Management conditions such as sign postings and marking of boundaries every 10 years
- Closure conditions
- Patrolling of streams and boundaries
- Enforcement
- Plan to work with local Conservation Commissions
- Providing maps to customers identifying Zone II's and land ownership

11.4 Water System Planning

Any system experiencing problems related to planning, operation, and/or management as determined by the Department should submit a water system master plan (Master Plan) for its review and approval upon request. The Department should work with the PWS and other parties to establish the level of details for this plan.

Planning is critical for all water systems. All water systems should have written long and short-term plans. The goal of planning activities is to identify present and future needs and set forth a means for addressing those needs. The results of proper planning will help ensure the efficient use of available resources and the orderly growth of the water system, while maintaining reliable and safe delivery of high quality water. Many of the items described in Chapter 11 are components of a Master Plan.

The Master Plan is a dynamic document that has to be both realistic, forward looking, and captures the vision of the PWS's needs over 5, 10, or 20 years. At a minimum a master plan should have the following sections:

1. Strategic Plan
2. Background Information
3. Capital Improvements Plan
4. Financial Plan

Note: Visit our Web site for a detailed master plan checklist: www.state.ma.us/dep.

11.4.1 Strategic Plan

A strategic plan is a long-range plan that documents a mission statement and outlines the goals and objectives to achieve the mission. Objectives are specific, achievable and measurable means to reach the goals. Together the goals and objectives provide guidance and a baseline to develop the work breakdown structures.

11.4.2 Background Information

Customer Profile

- Age, income levels, employment status, major employers and predominant activities that affect water quality and quantity. *This information is critical if a system plans to apply for federal/state low-income loans and subsidies.*
- Average water usage and peak demand periods
- Existing and future service area
- Current and projected population, growth and other changes that affect water demand

Water System Description and Analysis

- System design standards and descriptions
- Age of wells, plants, and facilities
- Extent of distribution lines

- Capacities of system; hydraulic model of system
- Vehicles and equipment owned by the system
- Major changes or challenges in treating or delivering water in the future
- Physical deficiencies in the system such as inadequate production capacity or significant amount of unaccounted for water

Water Sources

- Ground water source or surface water source or groundwater under the influence of surface water.
- Nature of watershed or wellhead area such as agricultural, residential, livestock, golf courses and factories etc.
- Water quality analysis including any reoccurring violations of drinking water standards
- Adequacy of water supplies given the projected demand
- Trends or threats to the water supply
- Location of alternate sources and use of interconnection(s)
- Wellhead protection plan, watershed control program and conservation plan
- Source Water Assessment report if available

Personnel and Management

- Organizational structure
- Staffing levels and qualifications, operator certification
- Record keeping and reporting
- Existence of operating policies, procedures or other reference manuals, (operations and maintenance, consultants and contractors)
- General responsibilities of personnel at all level
- Existence of emergency response plans, cross connection control program, drought contingency plans or water conservation plans
- Major policies and bylaw provisions of the governing board
- Customer service policies
- System operation and control
- Safety procedures

11.4.3 Capital Improvement Plan

A Capital Improvement Plan (CIP) is a document that thoroughly outlines, for a specified period, all necessary capital projects, the reasons for each project, and their costs. It should consider expanding service, upgrading water treatment, replacing worn-out equipment, adequacy of storage/ pressure and compliance with the SDWA and amendments. A CIP should contain a financial estimate for each year of the specified period and possible sources of financing for these improvements.

1. Capital asset inventory (Refer to *Fixed Asset Review* in this chapter.) identifies the capital resources owned by a community or water department, (e.g. buildings, machinery, vehicles, equipment and land). The inventory lists should include the following:

- Capital items and their acquisition date and cost
- Condition of equipment, replacement date and estimated replacement cost

Note: Visit our Web site for a Capital Assets Inventory Table: www.state.ma.us/dep.

2. System needs identification, cost estimation and prioritization identifies the following:
   - Current and future drinking water standards, compliance, and water demand
   - Current needs to maintain customer service (e.g., water meters and line replacement)
   - Future needs to improve customer service (e.g., new vehicles and remote sensors), and other items (e.g., new office, landscape equipment, or new hydrants)
   - Cost of each project organized into low cost projects to be paid from current or future budgets, and high cost items that will require external financing
   - Lead time needed for achieving each item
   - Prioritizing projects to be completed or started each year

Note: Most water systems under-spend on system improvements, pipe replacement, and upgrades. This leads to deterioration of the water system's infrastructure. Systems that are facing rapid changes may need to update their plan every five year. Others facing no changes may have a valid plan for 15 years.

11.4.4 Financial Plan

The financial planning process is an effective management tool designed to answer both short and long term questions regarding money or funding. Financial planning can be broken down into the following two elements:

- Annual operating plan or budget
- Capital plan

11.4.4.1 Annual Operating Plan or Budget

An annual operating plan or budget is a plan to estimate income and expenses for a future time period. Typical expense categories are annual debt service, salaries or personnel costs, office utilities, operations / maintenance and office supplies, chemicals, equipment leases, insurance, contract and professional services, telephone and travel.

Operating revenue is derived from the sale of water, connection fees, late payments, penalties, and reconnection fees. Non-operating revenue is derived from meter deposits or interest on checking or reserve accounts.

Rate increase, drought, uncollected bills, and new and lost customers affect revenue. Gains occur when revenues exceed expenses; losses occur when revenues are lower than expenses.

11.4.4.2 Capital Plan

A capital plan identifies the possible financing alternatives for the projects prioritized in the CIP. Funding sources include loans and grants from federal and state agencies, banks, foundations, cash, reserve funds, general obligation bonds, special assessments, promissory or short term notes, joint financing, privatization, and rate revenues. The capital plan, financial plan, and CIP are interrelated and should be prepared and reviewed together.

11.5 Financial Capacity

Financial capacity is the water system's ability to acquire and manage sufficient financial resources to achieve and maintain compliance with SDWA requirements. Financial capacity refers to the financial resources of the water system, including but not limited to the revenue sufficiency, credit worthiness, and adequacy of fiscal controls. The following items in Section 11.5 –11.7 are generally used to demonstrate that a PWS has adequate financial capacity.

11.5.1 Revenue Sources

11.5.1.2 Rates

In order to be successful, a water system should operate in accordance with sound business principles. It is generally recommended that a PWS charge a fair price for the services it provides. The rate should support the operational and maintenance cost of treating and delivering water to the customers, the system's debt service and meet future needs. The Department may require the PWS to do a "cost-of-service" review and/or a "rate study".

PWS should review and adjust their water rates based on the projected revenue needed the following year. The system should provide upon request a copy of their water rate structure and fee schedule for drinking water services. Rate adjustment in small yearly increments creates less resistance than large rate increases every few years.

Note: Systems regulated by DTE require that agency's approval prior to any rate changes, as required by M.G.L, Chapter 164, section 94 and M.G.L, Chapter 165, section 2.

11.5.1.3 Rate Structures - There are four basic rate structures:

- Unmetered or flat rates
- Uniform rates

- Ascending/increasing block rate
- Descending/declining block rates

Note: Although commonly used throughout the United States, descending/declining block rates are illegal for municipalities and water supply districts in Massachusetts. Ascending/increasing block rates and flat rates are the preferred rate structures because they provide a reliable source of income, promote conservation and are more equitable to residential users if structured properly.

11.5.1.4 Charges

Service Charge - Service charges recover the costs associated with the daily operation of the water system, regardless of a customer's usage. They include meter reading and service, billing, and administrative expenses. Usually, the service charges are based on meter size.

Hydrant and Fire Protection Charge - Water systems are designed to provide water at peak hourly flows, and to provide sufficient fire protection to extinguish a fire over a minimum two-hour period. The costs associated with fire protection should be charged to the customer who will benefit from the protection. This includes public and private fire hydrants, and sprinklers.

11.5.1.5 Fees

Connection Fee - Connection fees, usually based on service line size, are charged for connecting new users to the PWS. The fee should equal or exceed the actual cost of materials, labor and equipment required for the connection.

Backflow Prevention Device Testing Fee - All backflow devices should be tested annually by the water system. The fee charged to the customer should represent the full cost to test each device, including the cost of labor, vehicle, equipment and related administrative costs. The fee is usually per device, although discounts may be given for multiple devices.

Other Fees - The system may establish fees, based on actual cost, for duties performed at the request of the customer. These include fees for a final meter reading, meter test, and turn-on or turn-off service. Hourly fees should be set for service calls, including equipment. Fees should be reviewed annually. The PWS may impose late payment charges. Generally (see note below), a late payment charge is a penalty plus interest for a payment that is over 30 days late.

11.5.1.6 Other Revenue Sources - Water systems should seek income from other sources when appropriate and when it does not interfere with the primary function of delivering safe water. These income sources may include: rental of unused buildings or land for compatible farming or other uses; forest management activities such as timber harvesting, firewood cutting, and collection of nuts, berries, other products and user fees.

Note: The Massachusetts Department of Telecommunications and Energy (DTE) does not permit the water companies that it regulates to charge residential customers interest on late payments**.**

11.5.2 Accounting

Note**:** Systems regulated by DTE must adhere to DTE's accounting requirements.

11.5.2.1 Billing - Billing frequency should be reviewed annually and adjusted annually if necessary. PWS should consider computerizing the billing process via a software program so that the process is more accurate and efficient. Quarterly or monthly billing is recommended.

11.5.2.2 Accounts Receivable – PWS should consider computerizing the process of recording accounts receivable, as these should be recorded and tracked. Customers that are 30 or more days late should be sent dunning letters, and in some cases, termination notices for continued failure to pay water bills.

PWS should have a written accounts receivable aging policy. A list of aged accounts receivable should be prepared periodically. Past due notices should be sent to delinquent customers with outstanding bills past certain days and shut-off notices should follow if a customer fails to respond to the past-due notices.

11.5.2.3 Accounts Payable- The payment process should require valid documents (invoices) to pay bills and avoid duplicate payments. Each payment invoice should be approved and signed by the designated responsible party (e.g. superintendent/commissioners). Any contract-related invoice should be verified against the contract document before payment.

11.5.2.4 Financial Accounting and Record Keeping - General Accepted Accounting Principles (GAAP) should be adopted in preparing financial statements. For good management practices, trial balance and treasurer's report should be prepared on a monthly basis for review and operations evaluation. Balance sheet, income and expenditure statement, cash flow statement and a management letter should be prepared annually as part of the audit report. The annual report should be prepared no later than three months after the end of fiscal year. Deficiencies and/ or recommendations from the annual audit should be reviewed and addressed in a timely manner.

All municipal systems are encouraged to use an enterprise account for the PWS to ensure adequate capacity. The system should maintain financial books and records for auditing and financial planning purposes.

11.5.2.5 Enterprise Account - All municipal public water systems are encouraged to use an enterprise account. MGL, Chapter 44, S. 53F1/2 allows municipalities to establish a separate account for a drinking water system. Enterprise accounting gives the PWS the ability to demonstrate which drinking water costs are recovered through user charges.

Enterprise accounting also allows the surplus or retained earnings generated by the PWS to remain within the fund rather than closing out at year's end and becoming part of free cash in the general fund. A community can establish an enterprise fund by adopting Chapter 44 Section 53F1/2, or by enacting special legislation.

No later than March 1 each year, the appropriate enterprise officer or board should submit to the mayor or board of selectmen the estimated costs and revenues for the next fiscal year. Revenue estimates should be prepared for user charges, investment income, and any other enterprise revenues. Enterprise available funds should also be considered. This information is recorded on the tax recapitulation sheet.

The water department can appropriate reserve funds or retained earnings for operating costs to:

- Offset the need to increase user charges
- Fund capital improvements
- Reimburse the general fund for previous water department funding
- For enterprise revenue deficits (operating loss)

Accounting for enterprise funds is similar to accounting for the private sector. Revenues are recognized when earned and expenses are recognized when incurred ("full accrual basis of accounting"). Enterprise accounting also requires the establishment of fixed assets. No separate bank account is needed; however, enterprise fund monies should be listed separately in the general ledger.

11.5.2.6 Fixed Assets Review - Fixed asset accounting (Capital Asset Inventory) is required of all enterprise funds. Any new fixed asset should be recorded upon acquisition and depreciated over its useful life. A fixed asset can be defined as a specific piece of property that has a tangible nature, a life longer than the current fiscal year, and a significant value. Generally fixed assets are land, buildings, improvements, machinery and equipment. (Visit our Web site for Asset Inventory).

The PWS should do a complete physical inventory of each fixed asset to establish the initial database. Fixed assets should be recorded at their original cost. When historical cost records are incomplete, best available estimates should be completed by an independent reviewer/company.

The useful life of every asset should be determined so that depreciation expense can be calculated and recorded. Because enterprise accounting is based on the objective of income determination, it is necessary to allocate the cost of any fixed asset over the life of the asset.

Typical values of useful life attributed to the various fixed assets found in water systems are given below:

Description	Useful Life/years
Emergency Power	15
Field Equipment	10
Furniture and Fixtures	5
Hydrants	50
Instrumentation	10
Meters	7-15
Pumping Equipment	15-20
Pump Stations	20-30
Reservoirs and Tanks	100
Service Connections	50
Structures and Improvement	50
Transmission / Distribution Mains	50-100
Transportation Equipment	6-10
Valves	50
Wells	30

11.5.2.7 Budgeting - A formal budget system should be in place and should be updated annually. Periodically compare budget estimates with expenditures and determine balances. Reports should be presented to the higher management for review and approval. Budgets for the following fiscal year should be started in the spring to allow sufficient time for management and public review.

Generally, expenditures for a public water system can be grouped into seven main categories:

1. Personnel - salaries, over-time, payroll taxes, employee health insurance premiums, worker's compensation and training.

2. Supplies - includes the cost of small tools, chemicals if needed, and office supplies.

3. Operating Expenses - cost of electricity, utility expenses, water quality testing, vehicle and equipment expenses, all insurance costs, including liability insurance, physical damage insurance, vehicle insurance, board liability insurance and bonding of employees.

4. Contracting Services - costs of contracting with engineers and utility consultants, lawyers, accountants, and financial advisors.

5. Repairs- Includes the cost of pipe and repair parts required.

6. Debt Service- Include annual payments on bonds and annual payments on loans (principal and interest)

7. Direct/Indirect Costs - Systems with enterprise funds should identify both direct and indirect costs. Direct costs are associated to the water department; indirect costs are prorated among departments, and cannot be assigned directly to the water department.

***Note*:** A healthy PWS generally has a positive cash flow for the next 5 years, adequate capital to finance equipment replacement, an operating cash reserve, and an emergency cash reserve greater than or equal to the cost of replacing the most expensive piece of equipment.

11.6 Internal Controls

11.6.1 Collection Policies

Specific rules on dates of billing, deadlines for payments without interest, deadlines before disconnection and reconnection charge should be part of the bylaws and should be strictly enforced.

11.6.2 Bidding and Purchasing

Cities, towns and districts in Massachusetts should adhere to the public procurement process, M.G.L. Chapter 30B, when contracting for services or supplies. It includes procedures for choosing contractors, purchasing and disposing of property. The PWS should have a *Bidding and Purchasing Policy* that adheres to Chapter 30B requirements. A list of pre-qualified bidders for common type of services and suppliers should be maintained.

11.6.3 Contracting and Work Projects

Policies should be established for bidding procedures that insure the system gets quality work at the best price. Standard operations procedures should include proper procedures to assure that only valid and authorized invoices are submitted for payment. Any increase beyond the contract amount should be subject to review and approval by higher management.

11.6.4 Insurance Coverage

The PWS should have sufficient insurance coverage for structures, vehicles, boiler and machinery, and worker compensation.

11.6.5 Cash Receipts

Standard operating procedures should be in place for cash transactions, from date stamping to recording of bills, receipts, and payments. Whenever possible, no single person should be responsible for processing payments and posting accounts.

11.6.6 Payroll

Standard accounting procedures for payroll should be used in payroll operations such as signing time cards and calculating gross wages. Payroll functions should be computerized.

11.6.7 Abatements

Abatements are issued when an incorrect charge results in an over charge to the customer. The treasurer should use a formal abatement policy when handling abatement requests from customers. Any abatement request should be subject to review and approval by the commissioners. Official records should be kept for all abatement decisions.

11.7 General Financial Indicators

11.7.1 Financial Ratios

Financial ratios are used to gauge the financial health of water systems. There are two simple ratios to help determine the financial stability of the system: 1) the operating ratio and 2) the debt service coverage ratio:

- Operating Ratio = Total Operating Revenue / Total O & M Expenses

Generally, an operating ratio below 1.176, or 1.15 including debt is considered to be an indicator of weak financial health, and ratios above 1.5, not including debt, are preferable.

- Debt Service Coverage Ratio = Net Available Revenues/ Debt Service Expenses

Debt Service Coverage Ratio measures the ability of water systems to cover their debt service (principal and interest on loans and bonds) after all operating expenses is paid. *This ratio should exceed 1.0 and analysts consider a range of 1.0- 1.5 as acceptable.*

11.8 Capacity Assessment

The Department's Drinking Water Program (DWP) evaluates the technical, managerial and financial capacity of all public water systems with priority given to systems with significant violations or public health problems, systems with a history of non-compliance, systems experiencing major changes in operations and systems requesting DWSRF loans. As a result of these evaluations, The DWP provides technical assistance and education, prevention measures and corrective action plans to PWS systems in accordance with the PWS' compliance with federal and state drinking water requirements and the Department's compliance and enforcement strategy.

11.8.1 Drinking Water State Revolving Fund (DWSRF)

In accordance with the SDWA any public water system receiving DWSRF loans must demonstrate capacity.

11.8.2 Sanitary Surveys

The Department generally uses its' sanitary survey program to evaluate each PWS capacity. The capacity ranking of each PWS is based on information gathered through sanitary surveys and a review of the system's historical file.

11.8.3 Capacity Assessment Language

The Capacity of a PWS is assessed by its' degree of compliance with the SDWA and DWP requirements including the capacity indicators that were discussed in these guidelines. Systems are categorized as having "adequate", "conditional" or "inadequate" capacity. These categories generally have the following meaning:

11.8. 3.1 Adequate Capacity

- Complies with all major Department's drinking water regulations and is expected to comply well into the future.
- Demonstrates a willingness and ability to plan for the future, including capital improvement plans, emergency funds, enterprise accounting, employee training, and updated master plans.

11.8.3.2 Conditional Capacity

- Currently complies with all the Department's drinking water regulations; but has issues that are being monitored and rectified; or
- Currently complies but may not have addressed a foreseeable major need that will have to be addressed within the next five years; or
- Is not in compliance with drinking water regulations; but has demonstrated good faith in remedying issues through an enforceable agreements such as an Administrative Consent Order (ACO) and remains in compliance with the enforcement order; or
- Is not in compliance; but the deficiencies can and will be corrected within 12 months.

11.8.3.3 Inadequate Capacity

- Is not in compliance with drinking water regulations or cannot be expected to meet them in the future;
- Does not plan ahead for future impacts (e.g. growth and aging infrastructure) which could greatly impair their ability to provide water that meets state and federal standards.
- Substantial technical assistance is required in order to improve system performance.

Note: Systems with inadequate capacity are not generally eligible to receive DWSRF loans.

11.8.4 New Public Water Systems - Water Supply Business Plan

An applicant to develop a new public water system (community or NTNC) must demonstrate managerial, technical and financial abilities to comply with the SDWA and other drinking water requirements pursuant to 310 CMR 22.00. The applicant must submit a business plan in a format approved by the Department. The documents must demonstrate the systems proficiency in all three capacity areas: technical, managerial and financial. The plan must be submitted during initial stages of the new source approval process. (See Chapter 1, *Submission of Water Works Plans*) If a water system is part of a larger enterprise, only the water supply portion of the enterprise needs to be included in the business plan. Visit our Web site for a detailed water supply business plan.

Note: This does not apply to existing systems that are developing a new source.

11.8.5 Public Water Systems Applying for Variances and Exemptions

An applicant for a variance or exemption must demonstrate managerial, technical and financial abilities to comply with the SDWA and other drinking water requirements pursuant to 310 CMR 22.00. The applicant must demonstrate the system's proficiency in all three capacity areas: technical, managerial and financial.